INVESTIGATIONS INTO THE ETIOLOGY OF ENAMEL SPINDLES IN HUMAN TEETH

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INTRODUCTION

Enamel spindles is the name given to certain histological details found in the enamel at the amelo-dentinal junction. They occur mostly in the vicinity of the dentin cusp portion and seem to be in communication with the contents of the dentinal tubuli. This communication has been shown by Beust (1), Kantorowicz (2), Turkheim (3), Fleischmann (4), Hopewell-Smith (5), Roemer (6), Fish (7), Chase (8), Meyer (9), and others by stain penetration from the pulp through the dentinal tubuli (*fig. 1*).

The object of this investigation is to check the information imparted by other investigators on this subject and possibly to arrive at a more definite conclusion. This work is not concerned particularly with the purpose, distribution, occurrence, contents, and shape of the spindles as they are seen in human teeth nor whether they are normal or of pathologic origin.

ETIOLOGY

In the literature many different theories as to the etiology of enamel spindles may be found which for convenience may be grouped as follows: 1. Developmental defects, 2. Artifacts, 3. Results of resorption processes, 4. Penetration of dentinal tubuli into the enamel, 5. Penetration of dentinal fibrils into the enamel, 6. Penetration of dentin matrix into the enamel, 7. Post-odontogenetic condition. Each group may be in turn subdivided according to detailed differences in opinion.

1. *Development defects.* *A.* Check in calcification of enamel cells during development (not pathological), Caush, (10), *B.* Shrinkage of

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a greater amount of intercolumnar substance, Von Ebner, (11), Metnitz, (12), *C*. Pathological cavities, Charles S. Tomes, (13), Broomell, (14), *D*. Lack of organization during development, Taft, (15), Hopewell-Smith, (5), Williams, (16), *E*. Lack of calcification of enamel rods or widening of intercolumnar substance or dentin origin, Farber, (17), *F*. Spaces resulting from separation of enamel rods, Retzius, (18), Nessel, (19), *G*. Possible lack of calcification of enamel rods, Miller, (20), *H*. Lack of calcification of intercolumnar substance combined with poor formation of outer portion of enamel rods due to lack of functioning of enamel organ, Pickerill, (21), *I*. Lack of calcification of intercolumnar substance, Fleischmann, (4), Chase, (8), *J*. Imperfect lateral union of enamel rods and defective arrangement of the salts in the enamel sheath producing opaque areas, Bate, (22).

2. ***Artifacts.*** *A*. Cracks in the enamel, Linderer, (23), *B*. Grinding (results of), Frey, (24).

3. ***Results of resorption.*** *A*. Walls of dentinal tubuli of first formed dentin resisting resorption of ameloblasts, Walkhoff, (25), Turkheim, (3), Kantorowicz, (2), Euler & Meyer, (26), Munch, (27). *B*. Remnants of dentin ground substance and dentinal canals withstanding resorption by enamel, Sicher, (28), *C*. Remnants of resorbed dentin, Wedl, (29), Meyer, (9), *D*. Dentinal fibrils withstanding resorption processes of first formed dentin by ameloblasts, Meyer, (9).

4. ***Penetration of dentinal tubuli into enamel.*** *A*. Penetration of dentinal tubuli into enamel during development (normal reversion to lower orders of life), Mummery, (30). *B*. Penetration of dentinal tubuli between enamel rods during development, Roemer, (6), Fischer, (31), Mummery, (30) Humphreys and Wellings, (32). *C*. Prolongations of dentinal tubuli into enamel, Klencke, (33), Farber (17), Gaddes (34), Rywkind (35), Hanazawa (36), Baumes (37). *D*. Enlargements of prolongations of dentinal tubuli, Abbott (38), Tomes, John (39). *E*. Spaces (?) in enamel caused by penetration of dentin "fibres" into enamel, Carabelli (40). *F*. Penetration of poorly formed interprismatic substance by dentinal tubuli resulting in bulbous enlargements. Where they occur in well calcified intercolumnar substance they are remnants, Smreker (41). *G*. Penetration of dentinal tubuli into enamel as a result of foldings of enamel at the periphery of the dentin cusp portion, Kantorowicz (2), *H*. Prolonga-

tions of dentinal tubuli into enamel prisms, Noel (42). *I*. Dilatations of the prolonged dentinal tubuli into the enamel, Koelliker (43), Boedecker (44), Boedecker (44 a), McQuillen (45), Kronfeld (46), Fish (7). *J*. Penetration of dentinal tubuli into ameloblastic layer (pathological), De Terra (47).

5. ***Penetration of dentinal fibrils into enamel.*** *A*. Penetration of dentinal fibrils into enamel, Noel (42), Cutler, (48), Linderer (23), Stowell (49), McCrea and Robinson, (67). *B*. Penetration of enamel matrix layed down by ameloblasts by a number of dentinal fibrils bunched together, Kato (50). *C*. Penetration of dentinal fibrils into enamel and dilatations of the fibrils, Dependorf (51), Williams (16), Leigh (52). *D*. Penetration of dentinal fibrils into interprismatic substance (remnants or inclusions), Beust (1), Morganstern (53). *E*. Penetration of first formed soft enamel by dentinal fibrils. The spindle withstanding calcification processes (uncalcified organic matrix of enamel), Mummery (30). *F*. Penetration of dentinal fibrils between ameloblasts, Orban (54), Meyer (9), Lams (55), Eidmann (56). *G*. Penetration of dentinal fibrils into ameloblastic layer, Chase (8).

6. ***Penetration of dentin matrix into enamel.*** *A*. Penetration of dentin matrix into enamel before amelification, Maximow, (57). *B*. Dentin matrix fibers penetration between ameloblasts, Paul (58). *C*. Overdeveloped dentin pushing in between ununited enamel rods, Wedl and Heider (29).

7. ***Post-odontogenic condition.*** *A*. Post-odontogenetic anomaly, Tomes, John (39). *B*. Defects in new formed enamel-dentinoid substance produced by dentin after odontogenesis, Westin (59).

The most recent theories, however, are based on Lam's (55) work on odontogenesis in the cat. He concludes that the dentinal fibrils penetrate the intercellular substance of the ameloblasts sometimes even to the stellate reticulum through the stratum intermedium, ending in knot or bulblike formations. Eidmann (56), Orban (54), De Terra (47), and others accept this. Meyer (9) and Maximow (57), however, modify this conclusion in so far as including the dentin matrix fibers (Von Korff) penetration of the ameloblastic layer. Today this last conception is generally accepted.

From the tabulation of the various theories it may be deduced that

the time factor for their formation is mostly considered to be during early odontogenesis. Although the majority of the investigators have prepared and studied sections of developing teeth, their theories on enamel spindles appear to be based upon microscopic examination of ground sections of differently treated fully developed teeth. I have not been successful in finding demonstrations of their theories substantiated by drawings or photomicrographs. Only Lams (55), as far as could be determined, has seen the first sign of their formation during odontogenesis in the cat. Unfortunately this observation is presented by means of a drawing and not a photomicrograph. Furthermore this investigation was not made on human material, the disadvantages of which are obvious.

PROCEDURE

Since the predisposing factors for enamel spindle formation are generally accepted to occur early in odontogenesis, human embryos and fetuses were used. Forty-four specimens were obtained ranging between 7 weeks intrauterine and 19 days postuterine development. Of this number 14 have thus far been sectioned and studied. The time period of development lay between 7 weeks intrauterine and 17.5 hours postuterine. Specimens were fixed in 4 per cent formaldehyde solution from 4 days to 3 weeks. Where necessary, decalcification was done with 10 per cent HCl. The specimens were imbedded and prepared for sectioning and staining according to the routine paraffin technic. Stains employed were as follows: Haematoxylin-eosin, Van Gieson's alum haematoxylin picrofushin, Mallory's anilin blue, Unna's Wasserblau, Bilschowsky's method for collagenous fibrils, and the author's own modification of routine silver staining. Since we are mainly interested in connective tissue fibers of Von Korff and dentinal fibrils, stains showing these fibers and fibrils were principally employed. One half of the maxillae and mandible of the larger specimens was used for sectioning and study. Sections were cut sagitally between 3 and 12 microns. In all about 1500 slides of these specimens were made.

In addition some unerupted incompletely developed teeth were removed from the jaws and ground sections were made of that enamel and dentin developed thus far. These ground sections were not stained.

FINDINGS

From examination of differently stained sections in various phases of odontogenesis, until now the author has been unsuccessful in establishing the results of those investigators who believe that the dentinal fibrils and Von Korff fibers penetrate the ameloblasts during early human odontogenesis. The reasons for this statement are: *1.* Although in sections, here and there passage of the dentinal fibrils into the ameloblastic layer may be suspected, when one considers that the intercellular substance of the ameloblasts takes the stain equally

well and that there is possibility of artifacts occuring from treatment and cutting of sections, it is difficult to believe or interpret with certainty that there is such a penetration (*figs. 2* and *3*). *2.* Von Korff (65) fibers take the silver stain strongly, whereas the cellular elements take this stain weakly. Correctly stained sections do not show a penetration into the ameloblastic layer of Von Korff fibers. *3.* When the size of the enamel spindles are considered the dentinal fibrils and the Von Korff fibers would be expected to extend far into the enamel organ, in fact quite a distance into the stellate reticulum if this theory be correct. This condition has not been found in sections. *4.* Since a certain amount of dentin or pre-dentin is layed down before amelogenesis takes place, evidence of a penetration should be even more clearly visible in young sections. However, this obviously clear penetration of the dentinal fibrils or the Von Korff fibers in sections showing this stage of development was not evident. *5.* Penetration into the intercellular substance of the ameloblasts suggests a course taken by the enamel spindle following that taken by the enamel rods since each ameloblast is a factor in the formation of a single rod. The spindles do not follow the course of the enamel rods but frequently cross whole groups of them as shown by Hopewell-Smith (5), Kantorwicz (2), Meyers (9), Kronfeld (46) and others as well as examinations conducted in this work (*fig. 1*). *6.* In some ground sections where enamel and dentin are still in an early stage of calcification a communication exists between channels in the formed enamel and the dentinal tubuli. This has been mentioned by Beust (1) and substantiated by these findings. The channels however, may be identical with the intercolumnar substance of the enamel which fact removes the certainty of this condition as representative of true penetration by dentinal fibrils into the ameloblastic layer during early odontogenesis, the intercolumnar substance being a product of the enamel organ (Kline (60), Hopewell-Smith (5), and others) (*fig. 4*). *7.* The fact that a communication exists between the fluid contents of the dentinal tubuli and the spindles does not necessarily indicate a fibril or fiber penetration as an etiological factor any more than the fluid communication between epithelial and underlying connective tissue would indicate fiber penetration into or between the epithelial cells. *8.* The use of ground sections for study of the etiology of enamel spindles

where refraction, diffraction and light interference phenomona add greatest possibilities of artifacts and wrong interpretations due to various densities, thicknesses, curvature of enamel rods and the arrangment of the calcified particles in the sections, seems inappropriate (*fig. 1*). *9.* Since Meyer (9) has shown that the tuft formations in enamel at the amelo-dentinal junction seem to be due to a lesser calcification of the intercolumnar substance, the same reasoning that he uses in this case can be also applied to the enamel spindle formation as arguments against dentinal fibril or Von Korff fiber penetration as far as etiological factors in enamel spindle formation are concerned. *10.* If the presence of the dentinal fibrils or Von Korff fibers in the ameloblastic layer causes lack of calcification in the enamel, when later calcification increases in the dentin (Euler and Meyer (26), Von Beust (1), and others) then the spindles should also become calcified and as a result be found less frequently in older teeth. Likewise from Karlstrom's (61) work concerning the increase of hardness of teeth with age we should be less liable to find many spindles in older teeth if an increase in hardness indicates an increase in calcification. This has not been observed, in fact, Tomes (39) states that they occur more frequently in older teeth.

Penetration of the dentinal tubuli into the ameloblastic layer and theories associated with this view are not substantiated. The reasons for this view are: *1.* Roemer (6), Meyer (9), Hanazawa (36), Churchill (62), and others have shown the absence of the sheath of Neumann. The presence of the sheath was formerly believed by Walkhoff (25), Fleischmann (4), Hopewell-Smith (5), Mummery (30), and others. Since there does not appear to be a sheath of Neumann the error of assuming a penetration by this entity is obvious. *2.* If there should be a structure simulating a sheath but since shown to be probably a lesser calcified dentin surrounding the dentinal tubuli by Meyer (9), it is difficult to see how this can be responsible as an etiological factor in enamel spindle formation since no cells have been demonstrated that are responsible for its formation by a physico-chemical result. In view of this, penetration, suggesting power of motion, does not seem to apply here, there being no cells to guide the movement of this sheath into the ameloblastic layer.

The theory that they may be formed as a result of resorption of the

first formed dentin is not proved because: *1.* Orban (54) has shown that the scalloped appearance of the amelodentinal junction is predetermined by the form of the terminal end of the ameloblastic layer before any enamel or dentin is layed down. Meyer (9) later reversed his opinion on this theory agreeing with Orban (54). The resorption of the first formed dentin was originated by Von Ebner (11) and adhered to strongly by Walkhoff (25). The dentinal tubuli terminations are not cut off sharply as Von Ebner (11) and Walkhoff (25) supposed, this having been shown by Orban (54) and our findings. *2.* The ameloblasts were supposed to be responsible for the resorption of the first formed dentin according to Walkhoff (25). Orban (54), however, failed to see such characteristics of the ameloblasts. Furthermore in a section of a young ameloblastoma the ameloblastoid cells, which will never form enamel but which simulate the amelogenic cells, are arranged with a scalloped border (as shown by Robinson [68]). In this work the results are in favor of Orban's view. *3.* It is difficult to see how, if there should be resorption processes going on, it would be possible for the dentinal tubuli to withstand this process since there is no tubular sheath as Neumann believed. Furthermore enamel spindles should be seen at the amelo-dentinal junction in all positions instead of mostly at the dentin cusp portion. This is not seen in sections. *4.* If a resportion process should be possible why only some dentinal fibrils should withstand resorption and not more is hard to understand. Furthermore, why the dentin matrix fibers should be susceptible more so than the dentinal fibril is not plain. *5.* If some of the matrix fibers and the dentinal fibrils should withstand resorption as suggested by Sicher (28), Wedl (29), and others, here again we would expect to see enamel spindles distributed all along the amelodentinal junction instead of just at the dentin cusp portion. As shown by Hopewell-Smith (5) the amelo-dentinal junction is scalloped in all positions. *6.* According to examinations of my sections I have not been able to see any stains in the ameloblastic layer similar to those which stained the first formed dentin, (Van Gieson's alum haematoxylin picro-fuchsin stain), at least not in the form of enamel spindles. Here again the size of the enamel spindles and the clearness with which the remnants of dentin which withstood the presumed resorption process in the ameloblastic layer should be seen must be kept

in mind. 7. Where there is evidence of first formed enamel (pre-enamel) it has not been possible to see spindle formation. It is only when subsequent calcification takes place that the author has seen evidences of spindle formation. *8.* One cannot always see the spindle at the tip of the scallop but frequently arising between two summits of the scallop. If the scallops and spindles are due to resorption process then we would expect to see the spindles arise from the summit of the scallop since here presumably the first formed dentin has withstood resorption processes to a greater degree. *9.* Finally the scallop does not seem to express a similarity to Howship's lacunae found in bone resorptions but rather a means for mechanical support of the enamel as shown by Hopewell-Smith (5).

In this work it has not been possible to agree with those investigators who believe these structures to be artifacts due to cracks or grinding processes, for these reasons: *1.* Enamel spindles occur regardless of how carefully the grinding may be done as shown by White (66) as well as our own findings. *2.* Kato (50) and Boedecker (44) by careful embedding and decalcification processes have shown that the spindles as well as other structures withstand decalcification processes even when all of the enamel is dissolved out. This could not occur if these structures were artifacts. *3.* When stains are forced through the dentinal tubuli to the amelo-dentinal junction and subsequent grinding of these teeth is carried out for viewing purposes under the microscope, the stain can be seen in these spindles. This evidence has already been mentioned. *4.* The fact that enamel spindles occur mostly at the dentin cusp portion is likewise a factor in the refutation of the theory that the spindles are artifacts. Otherwise we would expect to see them in variable positions in the vicinity of the amelo-dentinal junction.

Thus far it has not been possible to show that the enamel spindles are due to defective functioning of the ameloblasts. The reasons are: *1.* Enamel spindles do not follow the same course as the enamel rods. It seems reasonable to expect them to follow this course if one or more of the ameloblasts were not functioning and presumably caused spindle formation. *2.* It does not seem reasonable to assume that a few ameloblasts would not function in the vicinity of the amelo-dentinal junction and not further peripherally. If we should see enamel

spindles distributed throughout the enamel and in no specific location then we might be inclined to agree with this supposition. *3.* As yet we do not know if the ameloblasts are responsible for calcification processes in the enamel rods or whether they play a role only in secreting a substance which later calcifies. If the ameloblasts are concerned in calcification processes to a great degree then we might expect to find the enamel spindles within the striae of Retzius. This we do not see. *4.* In hypoplasia of the enamel we see in many cases absence of enamel resulting in pits and linear defects. Abbott (38) and others are of the opinion that in these teeth there are more enamel spindles, Euler and Meyer (26) have shown that there are no more than the usual number of spindles found in such teeth. *5.* Kohler (63) examining teeth of persons having congenital syphilis likewise does not see any more than the usual findings at the amelo-dentinal junction in the enamel. *6.* Rywkind (35) and Kanemori (64) examining teeth of ovarian tumors do not find any more than the usual conditions present at the amelo-dentinal junction in the enamel. In the last three mentioned reasons where the ameloblast seem to be influenced in their function we would expect to find an increase in the number of enamel spindles if the supposition that the ameloblasts alone are responsible for calcification processes in the enamel were correct. From this work it appears that the ameloblasts are concerned more with the secretion of a substance which later calcifies than with the actual calcification processes. The reasons for this will be discussed later.

That there is a shrinking of intercolumnar substance or a widening of this substance which, with reservation for some investigators' variations in theories, is associated with a poorer calcification of the sides of the enamel rods during or after development, cannot be substantiated on the grounds again of the course of the enamel spindles.

That the spindles may be associated in their formation with the foldings which may occur at the amelo-dentinal junction during development as suggested by Kantorowicz (2) cannot be proven in this work since: *1.* We would expect to find them at the periphery of the enamel inward to the grooves. In this locality we do not see them. *2.* In the horizontal sections through the portions of the teeth which show a great curvature, there they should be also found. Instead we

find only tufts. *3.* This theory suggests that the foldings might cause an overlapping of the yet uncalcified enamel rods and when subsequent calcification takes place either light interference and diffraction phenomena are produced or a lesser calcification of the enamel in the foldings results. If this be so then, since there is great overlapping of enamel rods before calcification throughout the enamel as evidenced by the lines of Schreger, there should be more spindles throughout the enamel where there is greatest overlapping. This detail is not seen. Just why there should be lesser calcification of the enamel rods where there are foldings is not clear. *4.* In the dog where there is more occasion for foldings of groups of enamel rods due to the high pointed cusps we do not see more enamel spindles. *5.* This theory likewise suggests that some enamel has been formed and then due to forces from the underlying dentin these foldings must have been produced. It seems only necessary to mention that the dentin is formed to a certain degree first before amelification takes place. It is not clear as to whether that amount of formed dentin can move into the ameloblastic layer or, further still, after some enamel is formed, still more dentin would necessarily be formed and this probably assumed movement of the dentin would be even more difficult to understand. *6.* In addition the enamel is not layed down in bulk but rather bit by bit so that it would seem that any adjustment necessary as far as room is concerned, could be accommodated. This has been shown by Orban (54) (method of enamel formation).

Enamel spindles are possibly an indication of a disturbance in calcification processes in the enamel. In this theory this work supports beliefs of Hopewell-Smith (5). The reasons for supporting this theory are: *1.* When specimens are decalcified in preparation for imbedding and sectioning, where a small amount of pre-enamel is layed down, we see left behind quite a bit of substance which has not been acted upon by acid. The intercolumnar substance is especially in evidence in addition to quite an amount of substance in what will be the future enamel rods. Since this substance has not been acted upon by acid it is reasonable to deduce that it could not have been calcified to any great degree. However, a substance is still present and must have been the material layed down originally by the ameloblasts and probably the stratum intermedium. To give the identical

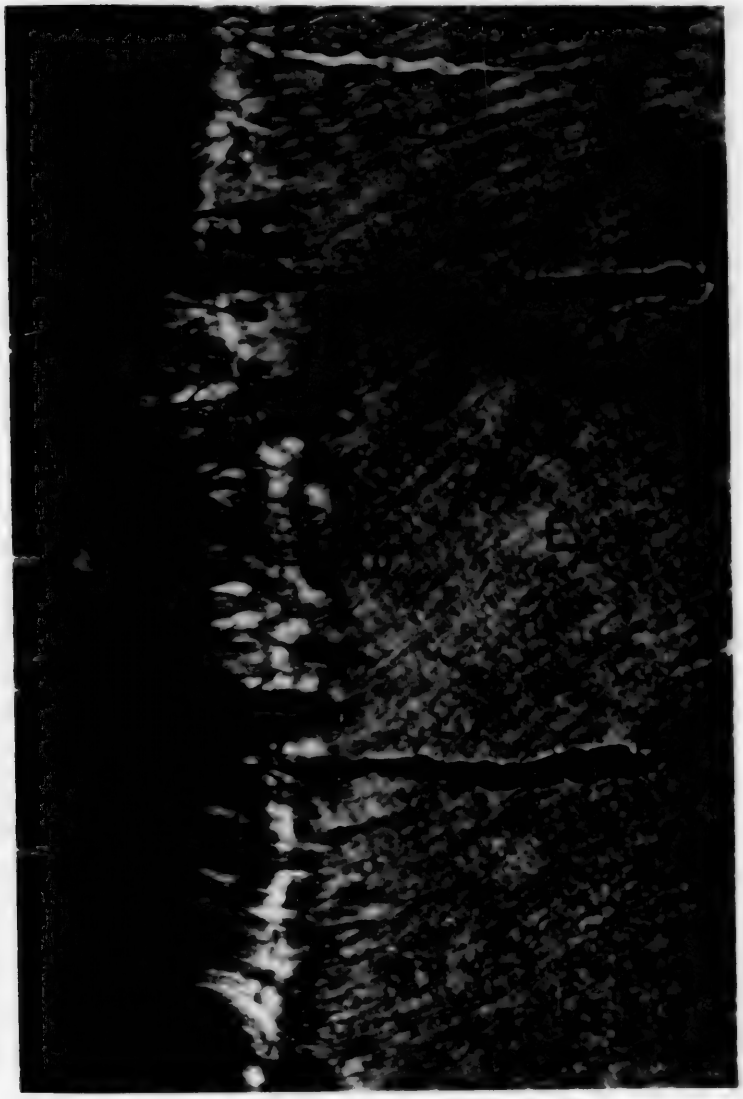

FIG. 1. Ground section cut bucco-lingually. E—enamel. D—dentin. AD—amelo-dentinal junction. ES—enamel spindle. (Negative and section by Hopewell-Smith.) Mag. approx. 460×.

FIG. 2. Section through mesio-lingual cusp of developing first maxillary deciduous molar. Foetus B-C measurement 16.5 cm. Stained haematoxylin-eosin. Objective 4 mm. Ocular 10×. Distance of plate to ocular 40 cm. SR—stellate reticulum. SI—stratum intermedium. AL—ameloblastic layer. DP—dentin papilla. At X we see what might be considered an evolutionary stage of enamel spindle formation. This however cannot be said with certainty.

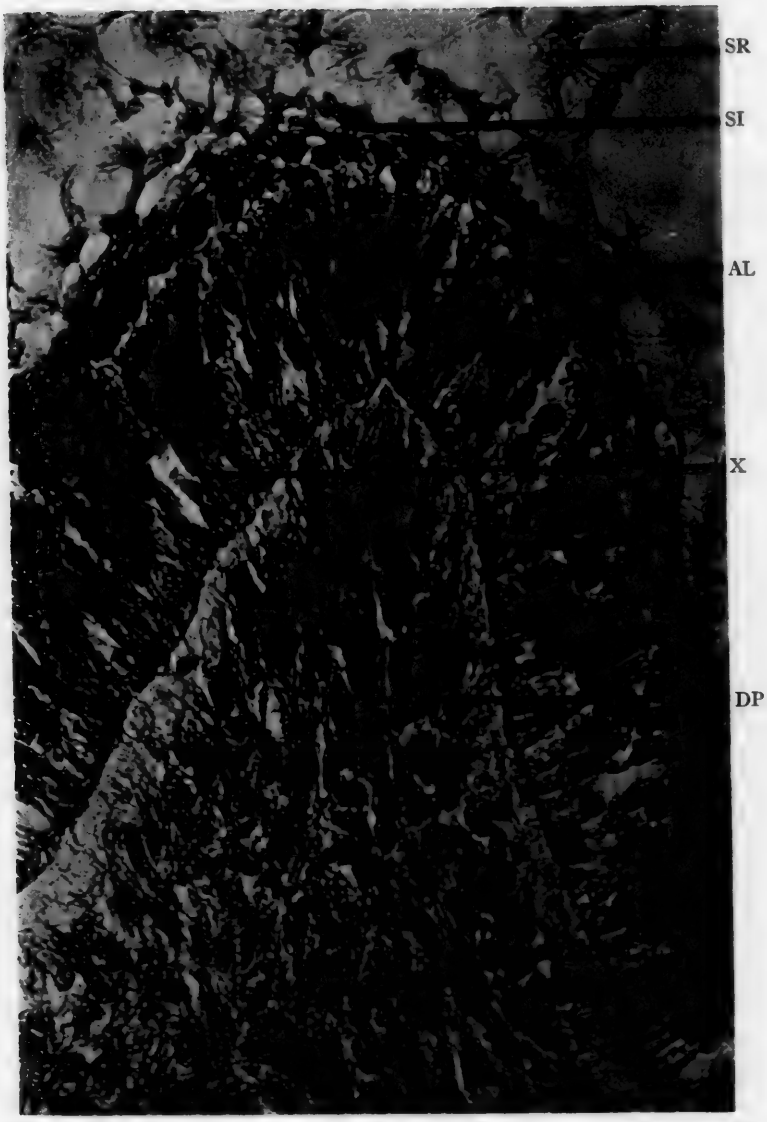

FIG. 3. Section through developing maxillary canine. Objective 4 mm. Ocular 10×. Plate distance from ocular 25 cm. Stained haematoxylin-eosin. SR—stellate reticulum. SI—stratum intermedium. AL—ameloblastic layer. DP—dentin papilla. At X is what might be considered an entity which might be an etiologic factor in spindle formation. This however is indefinite for conclusive interpretation. Foetus B-C measurement 16.5 cm.

cells a double role, namely laying down an uncalcified substance and in addition bringing about calcification in this substance is, it seems, more than has been intended for the cells. It is very difficult to see how the ameloblasts could at the same time produce and secrete a calcified substance in view of what is seen. However, since the exact mechanism of calcification is not understood, it would be just as erroneous to deduce that the ameloblasts have nothing to do whatever

FIG. 4. Unstained ground section through bucco-lingual plane of a developing second maxillary deciduous molar mesio-buccal cusp. Foetus B-C measurement 29 cm. Ocular 10×. Objective 4 mm. Distance of plate to ocular 25 cm. E—enamel. D—dentin. DT—dentinal tubuli. ER—enamel rods. IS—intercolumnar substance. Note indefinite appearance of amelo-dentinal junction. Also intimate relation between dentinal tubuli and what might be intercolumnar substance.

with calcification processes. An attempt is merely being made in this discussion to eliminate the ameloblasts as a direct major factor in calcification processes in the pre-enamel. In view of these statements a disturbance in calcification processes in the enamel need not be with respect to any course or distribution of the enamel rods, that is, once the ground framework has been layed down in which subsequent calcification takes place. *2.* In *figs. 5 and 6* it has been possible to show

FIG. 5. Unstained ground section through a fully developed molar. Objective aa. Ocular 4×. Plate distance to ocular 25 cm. E—enamel. D—dentin. AD—amelodentinal junction. SR—striae of Retzius. At X appears a detail which we will view under higher magnification in the next photomicrograph.

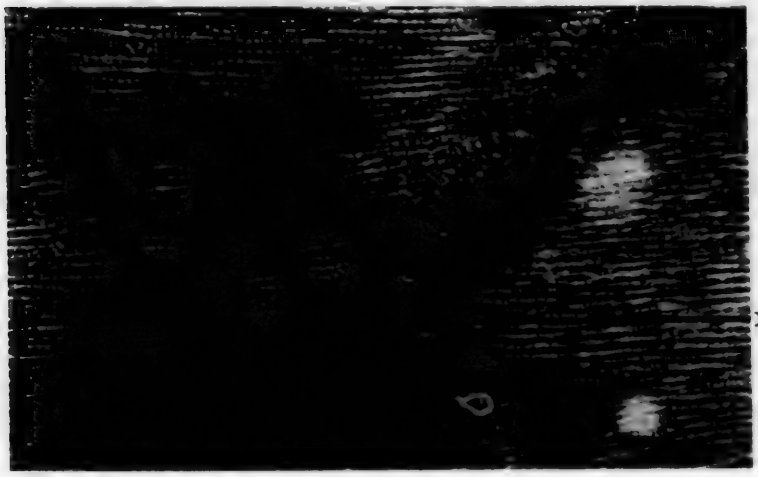

FIG. 6. Higher magnification of fig. 5. Objective 4 mm. Ocular 10×. Plate distance to ocular 40 cm. At X we see what now appears more definitely like enamel spindles.

structures standing out from the striae of Retzius which seem to be similar to the enamel spindles. In this location it can be seen that to attribute to these structures an etiology of a penetration of dentinal fibrils or Von Korff's fibrils seems improbable. However, here again these structures are not within the striae of Retzius but in the vicinity of them. Since the striae of Retzius do not show definite boundaries when using higher magnification might it not be reasonable to assume that probably spindle formation may be more closely associated with a disturbance in calcification processes, keeping in mind that we are not concerned with the mechanism involved in calcification processes because it is as yet indefinite. *3.* Where there seems to be a disturbance of calcification in individual enamel rods following that of the regular course of the rods, here the cross striations of the enamel rods give the calcospherite a more definite appearance. Whether or not this is evidence of spindle formation is difficult to say.

CONCLUSIONS

That the enamel spindles are due to remnants of previously penetrating Von Korff fibers or dentinal fibrils into the enamel organ cannot be substantiated from observations in this work.

Since the exact mechanism of calcification processes in the enamel is not thoroughly understood, we cannot say with certainty what influence plays a role in these processes in such a way as to produce these apparently lesser calcified areas known as enamel spindles.

Although observations lead to the theory that there may be an interference of calcification processes during development giving rise to enamel spindles, until enamel spindles can be produced at will or their number controlled by certain as yet unknown procedure during development, their definite etiology still remains problematic and purely theoretical.

The opinions or assertions contained in this article are the private opinions or assertions of the writer, and are not to be construed as official or reflecting the views of the Navy Department or the Naval service at large.—Article 113, U. S. Navy Regulations.

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THE EFFECT OF FEVER ON THE DEVELOPMENT OF THE RAT INCISOR[1]

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Numerous reports in the literature associate defects in tooth structure with periods of prolonged febrile diseases. Such alterations are believed to occur simultaneously with the development of the dental hard tissues (1, 2, 3). A great majority of these reported changes have been of gross character.

If we are to believe that there is a definite relationship between fever and tooth defects, certain questions immediately present themselves: Why do some individuals exhibit structural changes in their teeth, while others having an illness of comparable duration and intensity do not? Is the fever in itself the only agency responsible for these drastic alterations?

Unfortunately the hypothesis that fever produces dental change, in the past, was supported solely by clinical observations and has only recently been subjected to laboratory investigation (4, 5, 6). These studies were not reported prior to the present investigation so it was deemed advisable to attempt to reproduce the condition experimentally, with the hope of being able to throw some light on the mechanisms involved.

EXPERIMENTAL METHODS

The albino rat was used in this study because its oral anatomy has been studied in considerable detail (7, 8, 9), its life cycle is relatively short, and the incisors grow from persistent pulps and offer a convenient developmental stage for study (10). Artificial fevers were produced in these rats by means of an ordinary bacteriology incubator equipped with an air-pump to keep the air circulating from outside at all times. The

[1] Read at the 17th General Meeting of the International Association for Dental Research, Cleveland, Ohio, March 18, 1939. This work was supported by a grant from the Carnegie Corporation of New York.

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rats were placed in a wire cage in the center of the incubator where the temperature was most uniform. Water and saline were available in unrestricted amounts. Twenty-one rats were used in the experiment; 10 males and 11 females. Their weights ranged from 105 to 321 grams. The ages varied from 72 to 180 days. In this way it was hoped that any difference in susceptibility to heat due to age might become manifest. All the animals were fed an adequate stock diet, and were in good health as far as could be determined from appearance. The rectal temperature of each rat was taken before placing it in the incubator and at periodic intervals during the experiment. The incubator was started at a temperature of about 36° to 37°C., then slowly elevated to as high a point as the rat could tolerate, judging from its general appearance and temperature record. Five rats of the series were sacrificed at the height of their fever and decalcified sections made for

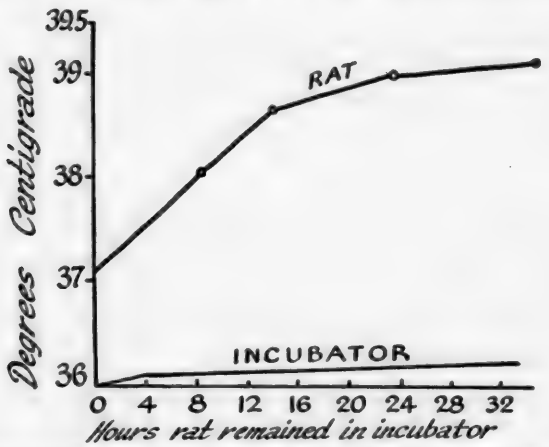

FIG. 1. Representative temperature chart showing relation of temperature of incubator to that of rat.

study of the changes in the pulpal tissues (1 to 5 inclusive, Table I). Fourteen of the rats were retained from 4 to 23 days after fever to study hard tissue changes (6 to 19 inclusive).[3] The rats in this group were each given from 1 to 5 treatments on successive days. Three of these 14 animals were given intraperitoneally, in doses of .5 to 1.0 cc. aqueous solution, injection of Alizarine Red S dye either before or after the fever.[4] This allowed a convenient method for marking the dentin which was in the process of development at the time (11). The remaining animals were kept as controls.

Ground unstained sections and ground sections stained with a saturated solution of basic fuschin in 50 per cent ethyl alcohol and distilled water were prepared (12). Also teeth from each rat were decalcified and stained with hemotoxylin and eosin.

In the production of fever it soon became apparent that there existed a marked individual variation in the resistance of the rats to the treatments. Some rats could tolerate

[3] Three of these died in the incubator during last fever treatment.

[4] The technic followed was essentially that of Isaac Shour, who also kindly furnished the dye.

TABLE I

Experimental data

RAT NO.	SEX	AGE	WEIGHT	DURATION OF FEVER	AV. TEMP. OVEN	AV. OF TEMP. READING ON RAT	MAX. TEMP.	WT. LOSS	WT. LOSS	TIME OF SACRIFICE FOLLOWING FEVER
Single Fever										
		days	*grams*	*hours*	°C.	°C.	°C.	*grams*	*per cent* ****	*days*
1	F	87	130	24	35.3	38.5	39.1			0
2	F	96	141	31	35.9	38.4	38.7	38.0	26.0	0
3	M	97	161	24	36.0	38.4	39.0			0
4	M	108	178	47	35.4	38.1	39.4			0
5	M	130	210	33	36.0	38.3	39.2	40.2	19.0	0
**6	F	72	105	41	36.9	38.7	40.3	24.5	22.0	20
7	M	72	109	75	37.2	38.2	39.0	28.0	22.0	21
8	F	73	105	72	36.1	38.6	39.0	21.6	19.5	13
9	M	90	151	56	36.3	38.4	39.8	22.0	14.3	21
10	M	93	125	67	36.4	38.3	39.7	29.0	12.0	14
11	F	99	145	47	36.0	38.7	39.8	30.3	27.0	10
12	M	102	168	23	36.0	38.4	39.2	31.0	18.0	12
**13	F	124	168	30	37.7	38.2	38.7	22.0	12.0	12
14	M	137	208	33.5	36.1	38.3	39.2	38.7	18.5	11
**15	M	180	321	26	37.2	38.7	39.2	41.0	12.5	15
Multiple Fever										
16	F	77	141	*56 21.5	37.3	38.8	39.9	37.0	30.0	4***
17	F	83	125	*71 9	37.5	38.9	40.0	37.0	28.0	7***
18	F	78	116	*21 12 12 10 11	38.4	38.7	40.2	34.6	29.0	5***
19	F	81	123	*31 12 12 10 11	37.6	38.8	39.8	33.0	26.0	23***
Controls										
20	M	96	160	0						
21	M	151	220	0						

* Successive Fever Treatments.

** Rats receiving Alizarine Dye in vivo.

*** Died in incubator during last treatment.

****% of original body weight.

a much higher temperature than others. It was also noted that on some days the difference between rat temperature and the incubator temperature was much greater than on others, probably depending upon the humidity which was not controlled. Due to these facts the total time in the incubator was variable. The usual procedure was to place two rats in the incubator at the same time. However, one invariably was able to remain for a longer period than its companion. The actual time in the incubator varied from 8 to 75 hours. A representative temperature chart is shown in *fig. 1.*

MICROSCOPE STUDY OF THE PULP

In the study of the pulp tissue of the 5 rats sacrificed at the height of their fevers, the following irregularities were noted: All the pulps

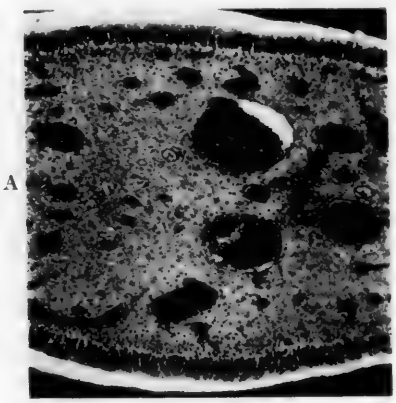

FIG. 2

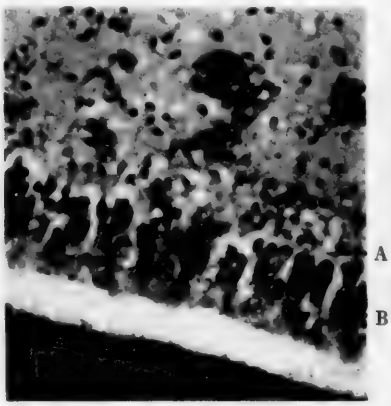

FIG. 3

FIG. 2. Low power section of pulp from rat sacrificed at height of fever showing edema at (A), and hyperemia (B). 66×.

FIG. 3. An area of the odontoblastic layer shown in fig. 2. (A) edema, (B) irregular odontoblastic layer. 390×.

are hyperemic and show vascular changes (*figs. 2 and 3*). The blood vessels are packed with cells and in longitudinal sections are irregular in outline. Many tiny, new vascular channels may be seen opening up throughout the pulps. Among the odontoblasts one capillary per every 6 to 8 odontoblast is not an uncommon finding. These expanded vascular channels appear to be exerting pressure on the cells, producing distortion of their otherwise regular arrangement.

There is edema of the pulpal tissue which undoubtedly causes further odontoblastic irregularity. The normal tissue spaces are enlarged and the soft tissue is compressed. Vacuoles reaching a diameter of

30 micra are common and are more frequent near the odontoblasts, where they have a tendency to crowd between the cells. This picture is similar to a beginning reticular degeneration (13, 14).

The irregularity of the odontoblastic layer is also noted in *fig. 3*. The cells present a general picture not unlike cloudy swelling; they are granular, enlarged, and ragged in outline, some of the nuclei taking a very pale stain and others appearing pyknotic.

The pulps recover from fever effects after 2 or 3 weeks. Pulps from the 14 rats sacrificed for hard tissue study, 4 to 23 days after fever treatment, retain very little evidence of these abnormal variations, eight appearing completely normal. Two show slight evidence evidence of persistent hyperemia, one being rat number 6, which manifests an intense, prolonged effect, and the third animal a slight

TABLE II

Fever line calculation

RAT NUMBER	D'	T	T'	D ACTUAL MEASURE	PER CENT ERROR
6*	265	20	20	265	0
13	200	18	11	335	2.4
15	140	15	7	300	.6

* Dye and fever given simultaneously.

pulpal edema. The remaining 3 died in the incubator during their last treatment and show pulpal changes similar to rats 1 to 5.

MICROSCOPE STUDY OF THE HARD STRUCTURES

On first examination of hard tissue sections, it was obvious that a definite change had been produced in the dentin. An attempt was then made to determine whether or not this change was in such a position in the dentin as to have been caused by the fever. Calculations were made from the locations of rings produced by the dye injections.

Fig. 4, illustrates an unstained ground section from rat number 15, which was given both fever and an injection of dye. In this photomicrograph the disturbance is represented at "A" and the dye line at "B." Here the duration of the fever was 26 hours, the average temperature during this time being 38.7°C. and the maximum tem-

perature 39.2°C. On the eighth day following the fever, 0.5 cc. of Alizarine Red S dye was given intraperitoneally. Seven days later the rat was sacrificed. The position of any defect in the dentin which

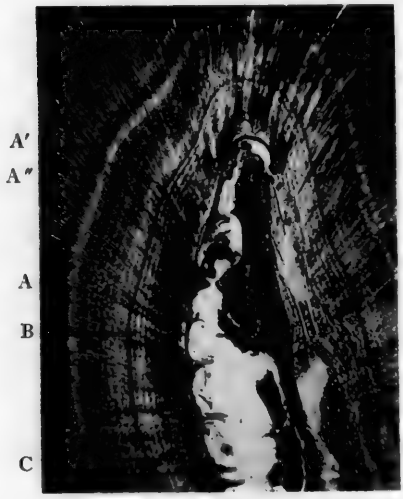

FIG. 4

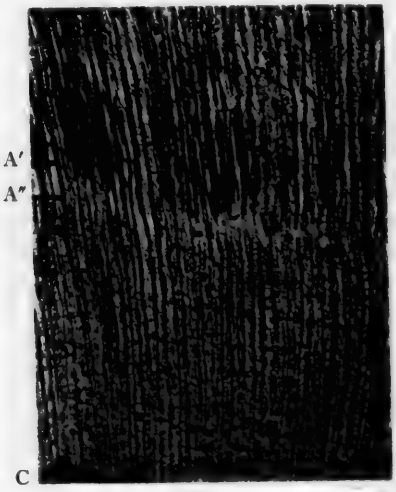

FIG. 5

FIG. 4. Ground unstained section from rat number 13 showing (A) Fever line, (B) Dye line, (C) Periphery of pulp, (A′) Outer portion of fever line, (A″) Inner portion of fever line. 66×.

FIG. 5. Higher magnification of fever and dye line as shown in *fig. 4*. (A′) Outer portion of fever line, (A″) Inner portion of fever line, (C) Dye line. 290×.

might have resulted from this stay in the incubator was calculated by the following formula:

$$D:D' : : T:T'$$

D—distance from the fever line (A) to the periphery of the pulp (C). (*fig. 4*). D′—distance from the dye line (B) to the periphery of the pulp (C). T—time in days from the fever treatment to the death of the rat. T′—time in days from the dye injection to the death of the rat.

Example: (*Fig. 4*)

$$D : 140 : : 15 \text{ days} : 7 \text{ days}$$

$$D = 298 \text{ micra}$$

D by actual measurement = 300 micra

From Table II it will be noted that growth of the dentin per day is not uniform for these rats as calculated from the position of the dye rings. This is probably due to the effects of the fever treatments. However, the ratio D/D′ and T/T′ are approximately equal in each case.

From these calculations it is shown that the disturbance at "A" occured simultaneously with the fever production. That is, the dentin

FIG. 6

FIG. 7

FIG. 6. Ground section stained with basic fuchsin. (A′) Outer portion of fever line, (A″) Inner portion of fever line. 66×.

FIG. 7. Decalcified section stained with H and E. (A′) Outer portion of fever line, (A″) Inner portion of fever line. 66×.

change at "A" is within 2 micra of where one would expect it to fall if it was caused by the fever. This error could easily occur as a result of a slight inaccuracy in one of the measurements AC or BC, or might be due to an oblique cut of the section.

It will be noted in this section that the dentin change at "A" is composed of 2 zones. The peripheral portion (A′) is darker than the surrounding tooth structure; the inner (A″) more translucent. When examined under higher magnification (*fig. 5*), more detail is manifest,

and a possible explanation for these facts becomes apparent. The tubules of the outer zone are wider than in the adjacent dentin. This is probably the explanation for the darker appearance in this region. The inner portion is more distinct than the outer in an unstained ground section. Here the tubules become smaller, terminate, or are bent. Some can be traced through the translucent area by proper focusing of the microscope.

A further study of these zones was made, using Beust's basic fuchsin staining method (6). A ground section stained with basic

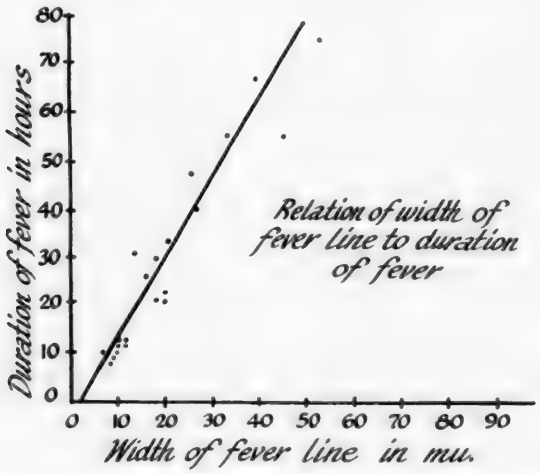

FIG. 8. Showing relation of width fever line to duration of fever

fuchsin is represented in *fig. 6*. Here the outer zone becomes more pronounced, taking a deep stain. The inner zone stains less intensely than the surrounding dentin, absorbing very little of the dye. In Beust's study of sclerotic dentin, such areas were chromophobic.

A third method used to investigate this change produced by the fever was by means of decalcified sections stained with hematoxylin and eosin (*fig. 7*). The duration of the fever in rat number 14 as represented in this illustration was 33.5 hours. The mean temperature over this period was 38.3°C. and the maximum temperature was 39.2°C. The animal was sacrificed on the tenth day following the

treatment. The experimental conditions for this rat are almost the same as for number 15. As illustrated in this section, the outer zone of dentin change stains more intensely red than the adjacent tooth structure, while the inner portion stains very lightly. Fish (15) finds that areas of increased calcification take up more hematoxylin stain than newly formed uncalcified hard tissue matrix.

The width of this dentin change in the fourteen animals comprising the hard tissue study group is approximately proportional to the durations of the fevers (*fig. 8*). A total of 24 fever treatments were

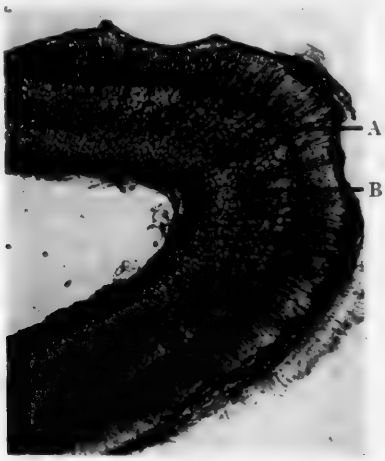

FIG. 9. Most extreme change found in the colony. (A) Dye line, (B) Interglobular dentin. 66×.

given to this group. Twenty-three of these produced dentin change as shown in the illustrations.

In some cases the dentin alterations are prolonged for a longer period than can be accounted for by the actual time of the incubation. A section from animal number 6 represents an extreme example of this continued effect (*fig. 9*). Here an injection of dye was immediately followed by a period of 41 hours in the incubator. During this time the average rectal temperature was 38.7°C., with a maximum of 40.3°C., which is also the maximum for any member of the colony. This exaggerated change takes the form of interglobular dentin, which

extends almost to the pulp. It was thought that this effect might be the result of a combined action of the previous dye injection and excessive fever since they were given almost simultaneously. However, similar results were obtained in other animals, although not so severe, where no dye was used.

DISCUSSION

The fact that the outer zone of dentin change stains dark with basic fuchsin, and red with hematoxylin and eosin and that the tubules appear wider here in an unstained ground section indicate that this portion is hypocalcified. The inner zone stains very lightly with basic fuchsin, and likewise with hematoxylin and eosin. Microscopically, in an unstained ground section, the tubules terminate, or diminish in diameter, and the area is more translucent. These findings indicate that this zone is hypercalcified.

Possibly this translucent zone represents the result of an attempt on the part of the pulp to throw up a layer of dentin which is similar to areas of increased calcification found by Van Huysen and Gurley (16) in cases where the pulp is stimulated by irritation from the outside.

The apparent odontoblastic damage, together with the hyperemia, and edema of the pulp may account for the early hypocalcified zone. Increased blood supply is considered as a hinderance to good calcification. When the animals are removed from the incubator, their temperatures drop rather suddenly, and the hyperemic pulpal condition is relieved. Although an apparent opposite view from the former consideration, this may be a factor in production of the hypercalcified inner portion.

Another factor to consider is that in periods of dehydration a great amount of salt has been excreted. This may be replaced in the blood stream by calcium and phosphorous thus depriving the pulp tissue of its proper materials for building dentin. After the temperature becomes normal again this difficulty is overcome.

A fourth consideration in this connection is that of the CO_2 combining power of the blood. In periods of increased metabolism, such as would be expected when the body temperature is increased, the CO_2 of the blood increases. This increase would make it possible for

the serum to hold more calcium in solution, thus depriving the dentin forming mechanism of the necessary material for building tooth substance.

SUMMARY

1. High fevers occurring in rats affect the development of the dentin by producing concentric double-ringed zones, which follow the developmental lines of the teeth. The outer zone is probably hypocalcified and the inner portion hypercalcified.

2. Pulpal changes take the form of edema, hyperemia, a possible early reticular degeneration, and irregularity and thickening of the odontoblastic layer, from which the pulp recovers almost completely within 2 or 3 weeks.

3. The width of dentin change is in proportion to the duration of the fever.

The author wishes to acknowledge the valuable assistance of Drs. Stafford L. Warren and Harold Hodge and Mr. F. W. Bishop during the preparation of this paper.

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SYMPATHETIC NERVE FIBERS IN THE ALVEOLAR NERVES AND NERVES OF THE DENTAL PULP[1]

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The smaller nerve fibers which terminate in the dental pulp have been variously interpreted. Investigators differ in their opinions regarding the numbers of the unmyelinated and the smallest myelinated nerve fibers respectively. The smaller myelinated fibers have commonly been regarded as numerous and the unmyelinated fibers as few in number. According to Brashear (1936), the unmyelinated fibers and the smallest myelinated ones together make up a large percentage of the nerve fibers in the dental pulp. In some cases the unmyelinated fibers make up almost one-fourth of the total number of nerve fibers present.

The function attributed to these small fibers is of importance because of the relationship which the positions of the termination of the fibers of these two types in the dental pulp must bear to their respective functions. The sensory function of the myelinated fibers seems to be demonstrated amply. The unmyelinated fibers have been described as of sympathetic origin and as vasomotor in function. Brashear, (1936), however, regards most of the smaller fibers as sensory, irrespective of their morphology. The large nerves which enter the apical foramina accompany the blood vessels in their course through the dental pulp, but it is not unusual to find bundles of nerve fibers which have deviated from the blood vessels and therefore lie free in the connective tissue throughout the pulp except in the outer cellular zone. The myelinated nerve fibers retain their myelin sheaths throughout their course in the larger nerves and even for a short distance after they deviate from the nerve trunks, but the myelin is lost before they reach the odontoblastic layer. The terminal parts of

[1] Presented in part at the St. Louis Section of the International Association for Dental Research, March 27, 1939.

the nerve fibers involved in the formation of sensory plexuses and the sensory terminations are devoid of myelin. According to Berkelback (1936), the unmyelinated nerve fibers accompany only the blood vessels with which they enter the dental pulp, and if they are found in the ground substance or connective tissue of the pulp it is only as they cross from one vessel to another. According to his account the unmyelinated nerve fibers take no part in the formation of the sensory plexuses at the periphery of the dental pulp, and terminate only in the walls of the pulp arteries as sympathetic fibers. He described the terminations as a reticulum of extremely fine unmyelinated nerve fibers, probably situated in the layer of smooth muscle. Other investigators likewise have found nerve terminations of simple types in the pulp arteries and also on capillaries (Wasserman, 1939) which they have regarded as sympathetic. The studies of Brashear, on the other hand, support the assumption that unmyelinated nerve fibers play a part in the formation of the peripheral sensory plexuses.

The autonomic innervation of the tooth has not been investigated except incidentally, as pointed out above. The present investigation has been undertaken to determine the rôle of the sympathetic nerves in the innervation of the teeth.

MATERIALS AND METHODS

The preparations used in the present study have been obtained from cats. The source of the sympathetic nerve fibers and the pathways by which they reached the dental nerves have been determined by dissections made with a low power dissecting microscope. Animals in which the arteries had been injected with a yellow starch mass were hardened in 10 per cent formalin and incomplete dissections first were made to expose the cervical sympathetic trunk, the common carotid artery and its larger branches, the mandibular canal, and the floor of the orbit. The dissected specimens were washed in distilled water, then treated with a weak solution of silver nitrate to stain the nerves. In these preparations the nerves have a dark brown color and the injected starch mass in the arteries remains yellow. The nerves, therefore, may be seen clearly, as they form plexuses around the arteries. The final course of the nerves from the external carotid plexus to the lower teeth was determined by studying serial sections of the inferior alveolar nerve and artery, and to the upper teeth by studying serial sections of the internal maxillary (arterial) plexus and sections of the superior alveolar nerves and accompanying arteries.

The data on the nerve fibers in the dental pulp have been obtained from pulps removed chiefly from the canine teeth. The small size or irregular shape of the dental pulps of the other teeth make them less desirable for sectioning. Teeth from which the pulps were to be removed were wrapped in cotton and carefully cracked in a vise. The pulps were freed by picking away the broken dentin. The pulps which yielded the best sections had considerable volume and were definitely turgid, whitish in appearance and glistening.

Silk threads tied to the ends of the pulps afforded a means of attaching them to short glass tubes and slightly stretching them in order to prevent tortuosity of the nerve fibers.

The location of the cells which give rise to the sympathetic unmyelinated nerve fibers in the alveolar nerves and the dental pulp was ascertained by the method of retrograde neuron degeneration (chromatolysis) following injury to the axones. In one series of cats the terminal parts of the axones were destroyed by removal of the dental pulp. This was done in the teeth of either the upper or lower jaw on one side or the teeth of both jaws on one side, in cats under nembutal anaesthesia.[2] In the earlier experiments the pulp chambers of the teeth were opened with the use of a dental burr and the pulps removed with a broach. In the later operations, the crowns were removed first and then the pulps were engaged by the broach and removed. In both operative procedures, the root canals were filled with cement. The animals used in these experiments were allowed to live from 12 to 16 days following operation. The cervical sympathetic ganglia were then removed. The superior cervical ganglion from the operated side in each animal invariably showed a slight enlargement as compared with the control ganglion. Supplementary studies were made of cervical sympathetic ganglia of a second series of cats, one in which the inferior alveolar nerve and artery and the surrounding connective tissue on one side had been cut, a second in which the superior alveolar nerves and arteries and connective tissue about them also were cut, and a third in which the mental nerves and arteries and the connective tissue around them were transected just outside the mental foraminae. These animals were allowed to live from 15 to 16 days before the ganglia were removed.

Ganglia taken from both operated and control sides were fixed in a 10 per cent formalin-corrosive sublimate solution and stained with erythrosin and toluidin blue.

Another series of operations were carried out to eliminate nerve fibers of given types from the alveolar nerves and the nerves of the dental pulp. Intracranial sectioning of the maxillary and mandibular nerves was performed in 9 cats, anaesthetized with nembutal, in order to cause the degeneration of fifth nerve fibers. These animals were killed from 2 weeks to several months after operation. The site of the operation first was inspected to determine the extent of the excision and the alveolar nerves and the dental pulps were removed and prepared for study. In 4 cats under nembutal anaesthesia, the superior cervical ganglion was removed or its gray rami severed on one side to bring about degeneration of the sympathetic nerve fibers peripherally. The animals were kept from 10 days to 3 weeks after operation before the tissues were taken and prepared for study.

For all of the studies on nerve fibers, sections were made of nerves treated by the osmic acid method to show the myelin sand by the pyridine silver technique to demonstrate the axones, especially the unmyelinated ones. Chloral hydrate was added to the fixing solution for the silver preparations.

The contents of the mandibular canal and also dental pulps were prepared for study of nerve terminations by the silver method of Bodian (1936) in which fixing solution No. 3, containing formalin, trichloracetic acid and 80 per cent alcohol, was used.

PATHWAY OF SYMPATHETIC FIBERS TO DENTAL NERVES

The exact origin and course of the sympathetic fibers which reach the dental nerves has not been described. Fibers arising in the su-

[2] These operations were carried out with the aid of Dr. R. F. Bleiker of the School of Dentistry.

perior cervical sympathetic ganglion are distributed in the cephalic region by way of the carotid arteries and their branches, including those of the external carotid artery which supply the teeth. Edwards and Kitchin (1938), however, have stated that, as far as they are aware, the presence of sympathetic fibers has not been demonstrated in the inferior alveolar nerve of any animal including man. These investigators found unmyelinated nerve fibers in the adventitia of the inferior alveolar artery which they interpreted as sympathetic. They advanced the opinion that not all of these fibers become incorporated

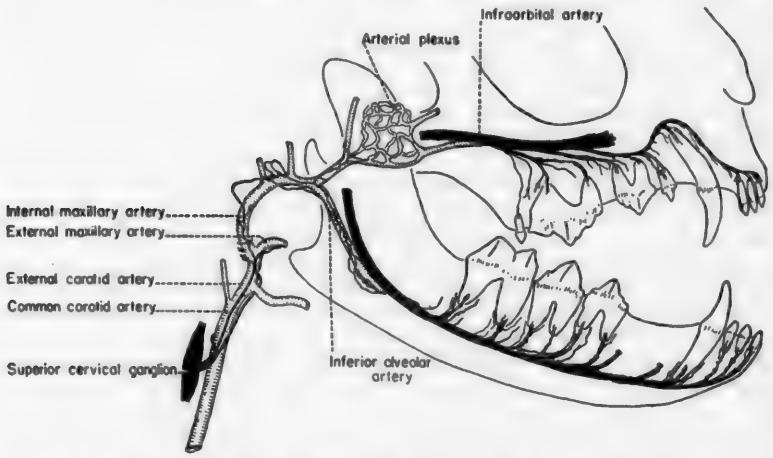


FIG. 1. Diagram to show the sympathetic nerve plexus about the external carotid artery and its larger branches which extends to the region of the alveolar nerves.

in the inferior alveolar nerve, but some remain with the blood vessels. Brashear (1936) described unmyelinated nerve fibers which he suggests to be sensory in both the inferior and superior alveolar nerves. He concluded that more of these fibers enter the nerves of the dental pulps than those of the peridental membranes.

According to our findings the sympathetic fibers which reach the dental nerves are derived from the plexus on the external carotid artery (*fig. 1*). Two nerves arise from the middle of the superior cervical ganglion, which, turning cephalad, join first the common carotid, and then the external carotid artery. The nerves about the

external carotid have few branches as far as the external maxillary artery where the large nerve to the submaxillary gland is given off but above, a plexus is formed which appears as a loose network of small nerves that can be traced upward to the internal maxillary artery and along its course.

Offsets of this plexus extend from the internal maxillary artery along the inferior alveolar artery. Near the mandibular foramen they are joined by the inferior alveolar nerve. The nerve plexus is found either in the adventitia of the artery or in the adjacent connective tissue. The further relationships of the sympathetic nerves to the inferior alveolar nerve can be determined only by a study of sections.

Above the origin of the inferior alveolar artery, it is difficult by dissection to follow the nerve plexus from the internal maxillary artery to the infraorbital artery. A few small nerves appear on the sides of the infraorbital artery as it extends forward with the infraorbital nerves. The teeth of the upper jaw are supplied by three superior alveolar nerves which branch from the infraorbital nerves before they pass through the infraorbital foramen. By lifting up the infraorbital nerves, the superior dental nerves are found above foramina in the orbital surface of the maxillary bone. The most anterior superior alveolar nerve traverses a foramen through the bone to supply the canine and the incisor teeth. The infraorbital artery gives off small arteries which reach the upper teeth with the superior alveolar nerves. The final disposition of the nervous plexus about the infraorbital artery and its relationship to the superior alveolar nerves also can be determined only in sections.

The nerves from the superior cervical ganglion which form the plexus on the common carotid artery, as they leave the ganglion, consist solely of unmyelinated nerve fibers. The larger nerves which arise from this plexus have a similar composition. The external carotid plexus, consequently, is composed mainly of sympathetic fibers.

In sections of the inferior alveolar nerve and artery it is apparent that, at the mandibular foramen, the plexus derived from the external carotid artery is represented by small bundles of nerve fibers scattered in the connective tissue, some of which are not in intimate contact with the bloodvessel. These small rami consist mainly of unmy-

elinated fibers, although some of them include a few myelinated fibers. Some of these rami become incorporated in the alveolar nerve, and extend into its branches. Within the inferior alveolar nerve, the unmyelinated fibers either form a peripheral crescent shaped mass or penetrate deeply into the nerve. Other small rami as far as they could be followed in the sections, do not join the inferior alveolar nerve but traverse the connective tissue. According to the accounts of several investigators, sections of the inferior alveolar nerves show mainly myelinated fibers of various diameters. The unmyelinated fibers present are mainly those which join the nerve from the external carotid plexus. Most of the small fibers are thinly myelinated.

Reighard and Jennings (1930) have shown that the internal maxillary, after giving off the inferior alveolar and middle meningeal arteries, divides into many small branches which form an arterial plexus around the maxillary nerve near its exit from the foramen rotundum. Distal to this arterial plexus the internal maxillary artery gives off the infraorbital artery.

Sections of the maxillary nerve below the foramen rotundum include numerous blood vessels belonging to the arterial plexus. In the connective tissue around the arteries, bundles of unmyelinated nerve fibers are present. These obviously are derived from the external carotid plexus. The infraorbital nerves and arteries have not been studied in sections. Sections of the superior alveolar nerves and arteries differ from those of the inferior alveolar nerve and artery in that they exhibit fewer bundles of unmyelinated fibers in the surrounding connective tissue. Unmyelinated fibers probably join the infraorbital nerves or their branches to a much greater extent than they do the inferior alveolar nerves.

EXPERIMENTAL DATA

Cells of origin

The experimental studies here reported have been carried out to determine which of the small nerve fibers that reach the alveolar nerves and the teeth are sympathetic in origin. The first experiments involved peripheral nerve destructions which resulted in retrograde changes in the corresponding ganglion cells, by means of which the sources of the sympathetic fibers and the numbers of ganglion cells involved could be determined.

1. Retrograde cell degeneration following tooth pulp removal. The ganglion cells which show degenerative changes exhibit dissolution of the chromidial bodies which extends from the nucleus outward until only patches of chromidial substance remain in the most peripheral parts of the cell. The nucleus usually is displaced toward the periphery. The cells affected have a characteristic "washed-out" appearance and are not to be confused with cells normally showing a peripheral distribution of the chromidial substance. Ganglion cells with a small amount of chromidial substance situated at the periphery are present in preparations of ganglia from the unoperated side; consequently, some investigations have estimated chromatolysis by the difference in the number of cells in this condition on the control and operated sides. Careful study indicates that this difference does not have to be considered because no cells in the normal ganglion closely resemble the degenerated ganglion cells.

Extensive chromatolysis was not found in any of the ganglia taken from the side on which dental pulps had been removed from either the upper or from the lower jaws. The results suggest that only a small number of sympathetic fibers are present in the dental pulps. Since normal pulps appear to have only a few unmyelinated fibers, pulp destruction in both upper and lower teeth on one side was carried out, but in spite of the extensive destruction the effects were slight. The ganglion cells which do show chromatolysis are mainly small or of medium size. Their smallest diameters vary from 18 to 30 microns and their greatest diameters from 26 to 40 microns. The position of these cells in the ganglion varies. Although widely scattered they are more abundant in the region from which the nerves to the external carotid artery arise and usually more in the caudal two-thirds of the ganglion than in the cranial third.

2. Retrograde cell degeneration following transection of the alveolar nerves, arteries, and surrounding connective tissue. In view of the small number of cells which showed chromatolysis consistently after removal of the dental pulps, it seemed desirable to carry further this type of experimentation. In one cat the inferior nerve and artery and the connective tissue about them were ligated and cut just proximal to the mandibular foramen. This operation was carried out through an incision made near the caudal end of the body of the mandible. By this means all of the sympathetic fibers which entered

the mandibular canal were severed. In a second cat the superior alveolar nerves, the small bloodvessels accompanying them and the surrounding connective tissue were likewise ligated and cut. By this method, all of the sympathetic fibers to the upper jaw are destroyed. In both types of experimental animals the superior cervical ganglia exhibited a large increase of cells showing chromatolysis, in contrast to the few chromatolyzed cells appearing in ganglia from cats with only the dental pulps removed. In sections of the superior cervical ganglion from animals in which the tissues entering the mandibular foramen had been cut as many as 40 to 50 cells or more were observed which showed the typical degenerative changes (*fig. 2*). The cells affected had the same characteristics as those observed when axones had been destroyed by dental pulp removal (*fig. 3*). The localization of the cells was not definite and they appeared to be scattered throughout various parts of the ganglion (*fig. 2*).

The results of these experiments suggest that a large number of sympathetic fibers are distributed in the alveolar nerves or associated perivascular plexuses, but only a few actually enter the pulps of the teeth.

3. Retrograde cell degeneration following transection of the mental nerves, arteries and surrounding connective tissue. In the third cat the mental nerves, the mental arteries and the immediately surrounding connective tissue were cut in order to determine the sympathetic fibers that leave the mandibular canal. A study of the superior cervical ganglion from the operated side showed rather extensive chromatolysis. The chromatolyzed ganglion cells also were similar in size and in position to those which had been observed previously. The results of this experiment support the assumption that a considerable number of sympathetic fibers emerge from the mandibular canal and have a peripheral distribution throughout the tissues related to the mental nerves.

In the studies of retrograde cell degeneration attention has been given to the inferior cervical sympathetic ganglion but sections of this ganglion showed no appreciable chromatolysis. Occasional chromatolyzed cells give evidence of some fibers which may reach the alveolar nerves from this ganglion, but the inferior cervical ganglion sends no appreciable number of sympathetic fibers to the alveolar nerves.

No complete counts of the cells have been made in the superior cervical ganglion showing chromatolysis as a result of the nerve section-

FIG. 2. A diagram of the superior cervical ganglion to show the position of the chromatolyzed cells after the sympathetic fibers, in the inferior alveolar nerve and about the inferior alveolar artery had been cut.

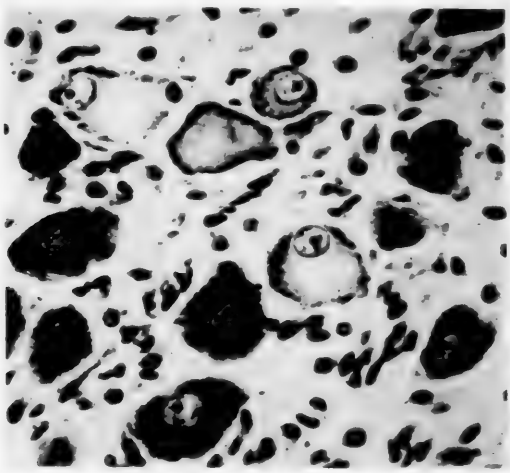


FIG. 3. The type of cells in the superior cervical ganglion which show retrograde cellular degeneration after sectioning sympathetic fibers about the inferior alveolar artery or in the inferior alveolar nerve. These are the same types of cells which show degeneration following dental pulp removal. (× 430.)

ing in the several types of experiments. Some consecutive representative sections from each ganglion have been studied from the numerical

standpoint. The relative proportions of degenerated and normal cells as they have been found are shown in Table I.

Fiber Differentiation

In the second series of experiments the nerve fibers of one type were eliminated from the alveolar nerves and the nerves of the dental pulp in order to isolate those of the other type for study.

TABLE I

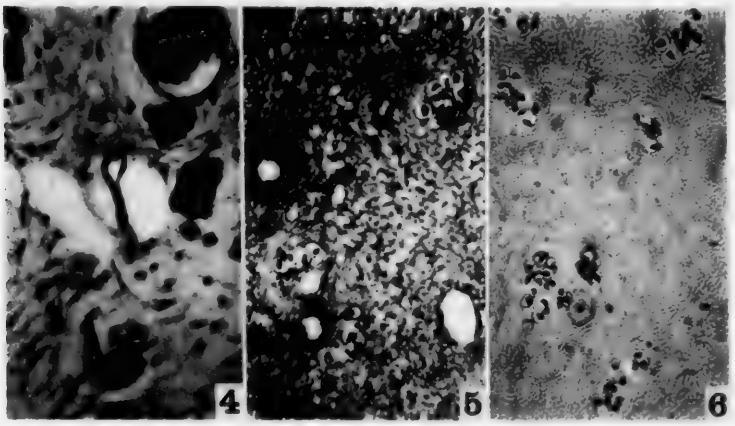
Relative proportions of degenerated and normal cells in superior cervical ganglia of experimental animals

	TOTAL NUMBER OF CELLS COUNTED	CELLS NOT SHOWING CHROMATOLYSIS	CELLS SHOWING CHROMATOLYSIS*	PERCENT CHROMATOLYSIS
Cat 2. Unilateral removal of pulps from teeth of lower jaw	1,840	1,818	22	1.1%
Cat 3. Unilateral removal of pulps from teeth of upper jaw	2,521	2,485	36	1.03%
Cat 1. Unilateral removal of pulps from teeth of both upper and lower jaws	804	789	15	1.8%
Cat 19. Same as cat 1	1,912	1,875	37	1.4%
Cat 17. Unilateral section of inferior alveolar nerve, artery and connective tissue	1,984	1,827	157	7.9%
Cat 4. Same as cat 1	2,416	2,391	25	1.07%
Cat 21. Unilateral section mental nerves, arteries and connective tissue	1,445	1,375	70	4.8%
Cat 18. Unilateral section superior alveolar nerves, arteries and connective tissue	1,398	1,323	75	5.4%

* In each section only those chromatolyzed cells which contained a well defined nucleus and nucleolus in addition to the cytoplasmic changes were counted.

1. Results of intracranial sectioning of the maxillary and mandibular nerves. After complete transection of the maxillary and the mandibular nerves intracranially the superior and the inferior alveolar nerves show practically no normal myelinated nerve fibers. Most of the myelinated fibers undergo complete degeneration. Pulps taken from teeth of the upper or lower jaws show no evidence of any remaining myelinated fibers. The absence of nerve tissue in the sections of the dental pulps is very striking. Only a few axones, as demonstrated by a silver method, show in the inferior alveolar nerves of the operated

side, although the small nerves in the connective tissue around the bloodvessels have as many unmyelinated nerve fibers as the same nerves on the unoperated side. The superior alveolar nerves from the operated side have a few more axones scattered in the interior of the nerve bundles than appear in the interior of the inferior alveolar nerve. The inferior alveolar nerves on the operated side sometimes show small masses of intact unmyelinated fibers at the periphery of the nerve. The axones which are left in the alveolar nerves or in the small



FIGS. 4–6

FIG. 4. Myelinated nerve fibers in normal dental pulp. Osmic acid. (× 287.)

FIG. 5. Nerve fibers of normal dental pulp shown by the silver method. (× 287.)

FIG. 6. Nerve fibers of dental pulp after removal of superior cervical ganglion from the same side. (× 287.)

nerves in the connective tissue after sectioning of the maxillary and mandibular nerves intracranially are sympathetic fibers. They are the axones which are brought out by the silver staining. In the sections of the dental pulps after the same operative procedure, the use of the silver technique rarely brings out axones in any great numbers and the dental pulp commonly is found nearly devoid of axones. It must be concluded from these observations that sympathetic fibers are not abundant in the dental pulp.

2. *Results of unilateral superior cervical sympathectomy.* After

removal of the superior cervical ganglion on one side the myelinated fibers of the alveolar nerves are similar on both the operated and control sides. Neither can differences be observed in comparisons of dental pulps from operated and control (*fig. 4*) sides.

Sections of the inferior alveolar nerve from the operated side prepared by the pyridine silver method show no appreciable evidence of loss of nerve fibers, since only a small number of fibers could have disappeared. In the small nerves in the connective tissue however there was a definite change. The closely crowded mass of unmyelinated nerve fibers had disappeared and only the few scattered myelinated fibers remain. In the sections of the dental pulps prepared by the silver technique nerve fibers were demonstrated as well on the operated as on the unoperated side. There was no detectable loss on the operated side due to the sympathectomy (compare *fig. 5* and *fig. 6*). The small nerve fibers which are thinly myelinated appear as clearly as on the unoperated side. They obviously arise from cells in the sensory ganglion of the trigeminal nerve.

Termination of the sympathetic nerve fibers found in the alveolar nerves and the associated perivascular nerves

Since only a few of the sympathetic nerve fibers end in the dental pulp it becomes a matter of interest to determine where most of the sympathetic nerve fibers in the alveolar nerves or the associated perivascular connective tissue terminate. The scarcity of sympathetic nerve fibers ending in the arteries of the dental pulp may be correlated with the paucity of smooth muscle which is found in the media of these pulp vessels. No other tissues which characteristically have a sympathetic innervation are to be found in the dental pulp; consequently, these terminations must be sought outside of the dental pulp.

Possible sites of sympathetic nerve endings are the walls of bloodvessels in the peridental membrane. Only a study of normal tissues has been made of this region but it is improbable that any large number of sympathetic fibers end here. As in the case of the dental pulp, only a few fibers at the most, enter the peridental membrane.

Some sympathetic fibers also terminate in the walls of the alveolar arteries and their larger branches. In Bodian preparations the peri-

vascular connective tissue in the mandibular canal shows a rich supply of unmyelinated nerve fibers. Fibers which are grouped together follow a straight course for some distance; others form a loose plexus in the connective tissue. The nuclei of the neurilemma cells are always apparent in constant association with the unmyelinated nerve fibers. Some of the nerves associated with the larger blood-vessels break up into conspicuous fibrillar strands (*figs. 7* and *8*) which

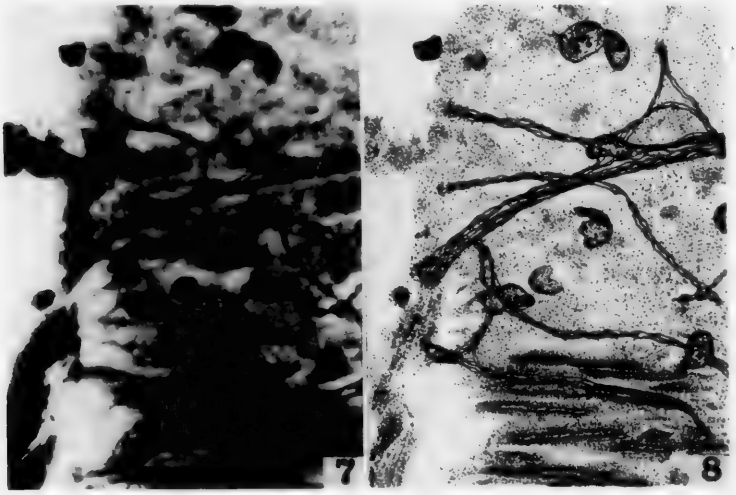


FIG. 7 FIG. 8

FIG. 7. Photomicrograph of termination of nerve fibers in the wall of the inferior alveolar artery. (× 680.)

FIG. 8. A drawing of the same section. The drawing represents several different levels of the same section to show more completely the "terminal reticulum" and also smooth muscle of the media of the artery.

penetrate deeply into the adventitia where they entwine about the arterial wall. Occasionally fibrillae seem to enter the media but the relationship to the smooth muscle cells has not been seen clearly in the preparations. These deeply placed fibers probably serve to establish vasomotor connections.

Another site of termination of sympathetic fibers which traverse the mandibular canal is the vascular tissue, the glands, and the smooth muscle connected with the hair follicles in the lower part of the face.

These areas are supplied by the mental nerves, which leave the mandible through two mental foramina. Experimental studies and sections of normal tissues taken from the mental foramina and slightly external to them show nerve fibers similar to those in the mandibular canal.

DISCUSSION

The experimental data reported in this paper support the assumption that the dental pulps receive few sympathetic nerve fibers. Study of the tissues in the mandibular canal indicates that sympathetic nerve fibers terminate in the walls of the alveolar arteries in greater abundance than in the pulp arteries. These fibers are mainly incorporated in small nerves from which they are distributed in the connective tissue and reach the musculature of the arterial walls. Not all of the sympathetic fibers join the alveolar nerves for their peripheral distribution. The published illustrations of the nerves in the dental pulp indicate clearly that the preparations of various investigators show similar conditions, but it is also clear from the descriptive accounts published that the interpretations of the preparations are not in complete agreement. In silver preparations the nerves often appear to contain chiefly myelinated fibers while at the periphery of the dental pulp, the fibers seem to be mainly unmyelinated. The differentiation of unmyelinated nerve fibers in nerve bundles of the dental pulp is not easy. Tracing them to their terminations likewise is difficult. If the nerve fibers which accompany the blood vessels are given particular attention, they frequently appear to be myelinated, like those which are separated from the blood vessels. The study of nerve terminations in the walls of the blood vessels becomes the more difficult whenever the pulp nerves and the blood vessels are adjacent to one another. Under these conditions, even in the most favorable longitudinal sections the simpler types of nerve endings are not unlike the ramifications of the fine nerve fibers, usually myelinated, that accompany the blood vessels. The results of this study indicate that sympathetic unmyelinated fibers and their terminal endings are not abundant in the dental pulp. Both osmic acid and silver preparations show a preponderance of small myelinated nerve fibers in this tissue.

The function ascribed to the sympathetic unmyelinated nerve fibers associated with the teeth, insofar as this has been discussed in previous papers has been regarded as vasomotor. This conclusion usually is not further elucidated. The fact that the dental pulps have few sympathetic fibers, as pointed out in this paper, does not alter this point of view since the alveolar arteries undoubtedly have sympathetic innervation and the effects of vasomotor impulses on the latter arteries must be exerted also on the pulp arteries and arterioles.

The influence of the vasomotor nerves supplying the tooth germs on the development and eruption of teeth has been the subject of investigation by several workers. In a recent study, Edwards and Kitchin (1938) found that removal of the superior cervical ganglion in kittens resulted in acceleration of growth of the permanent tooth germs on the operated side in 100 per cent of the cases. They explained this on the assumption that sympathectomy released the vessels from vasoconstrictor impulses and resulted in vasodilatation, thus supplying more nourishment for the developing teeth which accelerated their growth. It is interesting that these same investigators found that resection of the inferior alveolar nerve alone yielded inconstant results. This they explain as due to the possible lack of vasoconstrictor fibers in the nerve, and the fact that resection of the nerve alone, regardless of whether or not it includes any sympathetic fibers within its sheath, does not eliminate all of the sympathetic fibers which enter the mandibular canal. These findings are in agreement with the anatomical studies presented in this paper.

SUMMARY

The data presented in this paper support the following conclusions:

1. The alveolar nerves include sympathetic nerve fibers derived from the superior cervical ganglion via the plexus on the external carotid and its branches.

2. Few sympathetic nerve fibers actually enter the dental pulp, as indicated by the findings that: (a) Nearly all of the nerve fibers in the dental pulp disappear following section of the trigeminal nerve distal to the semilunar ganglion. (b) Removal of the superior cervical ganglion results in no appreciable change in the distribution of nerve fibers in the dental pulp. (c) Removal of the pulps of all the

teeth on one side results in but slight chromatolysis in the superior cervical ganglion on that side.

3. Ligation and section of the alveolar nerves and blood vessels and surrounding connective tissue results in extensive chromatolysis in the ipsilateral superior cervical ganglion.

4. Ligation and section of the mental nerves and blood vessels and surrounding connective tissue results in considerable chromatolysis in the ipsilateral superior cervical ganglion.

5. Sympathetic nerve fibers terminate in the walls of the alveolar blood vessels; others are distributed via the mental nerves.

6. Most of the nerve fibers in the dental pulp, including the smallest, are myelinated. Previous investigators have established their sensory function.

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STUDIES ON DENTAL CARIES

X. A Procedure for the Recording and Statistical Processing of Dental Examination Findings

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INTRODUCTION

In 1936, the authors undertook to plan a study of the way dental caries attacks complete population groups such as found in typical urban communities in the United States. The execution of this investigation was visualized in terms of several steps: Actual observations on the condition of the teeth of a large number of persons; translation of these direct observations into written records; summarization and tabulation of the recorded findings; and finally, interpretation of the data as a whole. Although it is clear that all these steps are interrelated, it is apparent that each is an entity in itself having individual provinces and problems. The second and third steps are closely related and together represent what might be designated the "statistical engineering" aspects of the study. The present paper deals with this province. It is concerned largely with a description of a particular record form and the machine processing methods developed for the analysis of dental observations recorded on this form.

THE EXAMINATION AND RECORDING PROCEDURE

Preliminary considerations: Methods for recording observations on biological material may be simple or complex depending on the variables under study and on the particular objectives of the investigation. Dental caries, a condition from which few individuals of the United States are free, is exceedingly variable in the way it attacks different persons. In addition, the several morphological types of teeth and coronal surfaces in both the deciduous and permanent dentitions have different caries susceptibilities. Furthermore, the evidence of caries may be manifested in a variety of ways: As teeth

and tooth surfaces with open carious cavities, as teeth and surfaces filled and as missing teeth extracted because of extensive destruction by the carious process. The design of a record system should take account of these facts and provide for detailed observations on the 20 deciduous and 32 permanent teeth and their 260 coronal surfaces. Because physical cumbersomeness is an almost inevitable characteristic of such data, detailed analysis and interpretations are difficult to achieve without the use of machine punch card methods.[1]

In the development of a record form for a community dental study it is desirable to consider several other items. It is evident, for example, that dental examinations should be made with great care, with dental mirror and explorer, and by dentists especially trained in the work. Because of the value of the dentist's time, efforts were made to eliminate from the duties of the examiner those tasks which might be accomplished by a clerical assistant. To this end, the examination procedure was set up so as to provide each examiner-dentist with a clerk for recording observations on the form.

Preliminary to the final adoption of a record form a decision had to be made as to whether or not the schedule would provide for a single examination or several successive examinations on the same subject. A survey of this matter led to the view that a single examination schedule should be used. This decision was predicated on the conviction that if seriatim data were desired such material could be collected and analyzed by accumulating successive single examinations on the same individual.

The problem of translating the direct observations of the dentist into the code symbols which form an essential part of the punch card method led to the preparation of a form which falls into the class designated in statistical nomenclature as the "self-coded" or "pre-coded" schedule. The record system finally adopted requires that the dentist-examiner learn a code corresponding with his direct observations on the teeth and mouth. The appropriate symbols making up the

[1] An extensive description of a method for the machine processing of dental statistics is given by Hyatt and Lotka (1). The method of these workers was designed for the analysis of data on adults. Since the objectives of the present study called for the examination of persons covering the complete age span, it was found necessary to adapt and expand the Hyatt and Lotka techniques.

code are called out to the clerical assistant who records them on the examination form. In the transfer of the dental findings to punch cards, the code symbols appearing on the examination form are punched directly onto the punch card.

Another item affecting the design of the form concerns the problem of recording negative information. In usual clinical practice the observer is interested largely in positive findings. Frequently, for example, the number of persons affected by a particular moribidity is determined; those not affected may not be counted. With reference to the teeth, and where the purpose of the examination is a determination of the number of teeth requiring reparative service, counts of only defective teeth may be made. The recording of observations in this way may lead, especially with regard to data on children, to serious limitations in the analysis since the amount of caries observed is undoubtedly a function of the number and morphological types of teeth present in the mouth irrespective of their condition. Thus it was recognized in the present study that the same basic principles which have been found to apply in epidemiological studies of other diseases should be considered in investigations on the natural history of dental caries. In more specific terms, the investigation was visualized not only in terms of individual persons but also in terms of populations of individual teeth; and in children 2 populations of teeth are involved, the deciduous and permanent. The record form was designed, therefore, to give an enumeration of the teeth present in the mouth as well as those not present, and to give details on both normal and pathological conditions.

Examination form and code: On the basis of the considerations given above, and others, the dental examination form shown as *fig. 1* was finally adopted. As used, the form is printed on a light weight card having the dimensions of 5 x 8 inches.

The upper one third of the card contains spaces for recording common identifying items as well as for notations on the use of the tooth brush, the state of the oral cavity with respect to general cleanliness, the presence of gingivitis, and so on. With the exception of the name, address and occupation of the subject (school attended and occupation of the parent in the case of children) and the name of the private dentist or clinic attended, the information given in this section of the

Name John Doe — Examiner Dr. Cody — Date Nov. 10, 1937

School: Antietam | Grade: 2 | Age: 10 | Sex: m | Color: W

Address: 386 Blank St. | Occupation: Parent Laborer

Toothbrush: (Daily) Occasionally Never — Dentist: Private — Clinic — (None)

Occlusion: I II III (IV) — Gingivitis: Severe (Mild) Free — Debris: I (II) III IV

C. Incisor	L. Incisor	Cuspid	D. Molar 1	D. Molar 2	Molar 1	Molar 2	Molar 3
Upper Left							
P3	P3	D4 3	P3	P3	P4 x	0	0
Upper Right							
P3	P3	D4 3	D4 x 2 3	P3	1	0	0
Lower Left							
P3	P3	0	0	0	1	0	0
Lower Right							
P3	P3	D3	D4 x 3	D3	P4 x 1	0	0
SUMMARY							
6 4	7 0	0 0	13 2	3 0	0 0	11 2	19 4

Special notes:

FIG. 1

form is recorded simply by writing a few numbers or by checking a code symbol. For example, after an inspection of the mouth the den-

tist specifies the general condition as falling into one of the following classifications of "debris": I—Teeth are very clean and free of stain. II—Teeth have slight debris and stain. III—Teeth have considerable debris and stain. IV—Teeth are excessively dirty. The procedure for recording this item is completed immediately after the dentist-examiner finishes his general inspection of the mouth. He calls out, in the case of a very clean mouth, "Debris I" and the clerical assistant encircles the appropriate Roman numeral "I" on the examination form.

The middle section of the examination schedule is composed of 4 horizontal rows of blocked areas which are used for recording details on the condition of the teeth. It may be observed that for each tooth space in the mouth there is a corresponding blocked area on the examination form. In all, there are 32 of these areas, one for each of the 32 tooth spaces in the mouth. Each of these areas is further subdivided into 2 rectangular columns by a broken vertical line.

For the purpose of describing this section of the form in greater detail the discussion which follows will be centered on one of the blocked areas and more particularly on the 2 rectangular columns into which each of these areas is divided. These 2 columns will be designated: "a" for the left hand column, and "b" for the right hand one. The "a" columns are used for recording 2 major items of information about the appropriate tooth spaces in the mouth. One (and only one) of the following symbols is selected and placed in the upper part of this column to indicate whether the tooth space contains a deciduous or permanent tooth or whether the tooth space is unoccupied by a tooth: D—deciduous tooth occupies space. P—permanent tooth occupies space. 0—tooth space is unoccupied because the deciduous tooth has been lost and the permanent tooth is as yet unerupted. 1—tooth space is unoccupied because the permanent tooth has been lost. 2—tooth space is unoccupied because the deciduous tooth which may be expected to occupy the space has not yet erupted. In recording the results of a particular examination, one of the above symbols must appear in the upper part of each of the "a" columns on the examination card. When this plan is followed, the examiner is able to account on the record form for every tooth space in the mouth. It is evident that this system makes it possible to give a complete

description of the tooth populations, both deciduous and permanent, in the subjects examined. In addition, data are made available for descriptions of the eruption and exfoliation of the deciduous teeth and the eruption and loss of the permanent teeth.

A second set of symbols was designed for the lower part of the "a" columns to furnish information, according to the following code, on certain major conditions of the teeth present in the mouth: 3—tooth is free of pathosis. 4—tooth shows active caries. 5—tooth contains a filling or fillings. 6—tooth shows gross hypoplasia of enamel. 7—tooth has one or more pits in which the explorer catches (not definitely diagnosable as caries). 8—tooth shows arrested caries. 9—tooth is non-vital and indicated for extraction. According to this system, it is always necessary to have one or more of the above symbols in the lower part of the "a" columns if either "D" or "P" appears in the upper part of the column. Thus, if the symbol "0", "1", or "2" appears in the upper part of this column the meaning carried is that no tooth is present in the particular tooth space in the mouth and no further description is necessary. However, if "D" or "P" appears in the upper section of the "a" column, the condition of the tooth must be described by one or more of the symbols listed immediately above. For example, one of the "a" columns might carry the symbols:

This symbolism would mean, in translation, that a permanent tooth was present in the particular tooth space in the mouth, that the tooth showed one or more carious surfaces, one or more filled surfaces and that it was non-vital and indicated for extraction.

The "b" or right hand columns of the blocked areas are used for symbols denoting the specific tooth surfaces involved by caries and/or fillings. The code used for this purpose is as follows: V—tooth has been affected by caries on all 5 coronal surfaces to such an extent that only the root or roots remain in the jaw. X—tooth is affected by caries on the occlusal surface. 0—tooth is affected by caries on the

lingual surface. 1—tooth is affected by caries on the buccal surface. 2—tooth is affected by caries on the mesial surface. 3—tooth is affected by caries on the distal surface. 4—tooth has been filled on all 5 surfaces (crown restoration). 5—tooth has been filled on the occlusal surface. 6—tooth has been filled on the lingual surface. 7—tooth has been filled on the buccal surface. 8—tooth has been filled on the mesial surface. 9—tooth has been filled on the distal surface. The "b" columns must always contain one or more of the symbols given immediately above whenever "4" and/or "5" is recorded in the corresponding "a" column. Thus, the complete description of a particular tooth might appear on the record form as follows:

P 4 5	X 9

This particular grouping of symbols would indicate, by the "a" column, that a permanent tooth was present in the particular tooth space and that the tooth had active caries and also contained a filling; by the "b" column, that the caries was located in the occlusal surface, that the filling was in the distal surface.

Illustrative example of use of form and code: The presentation of a completely filled out form (*fig. 1*) is perhaps the most convenient way of illustrating the form and code used. In filling out the middle section of this form the dentist-examiner observes first the tooth space in the mouth where the maxillary left first incisor is located. He finds in this tooth space a permanent incisor free of pathosis. He therefore calls out to the clerical assistant "Central incisor, P 3." These code symbols are written into the appropriate "a" column of the first blocked area on the left in the uppermost row of the 4 horizontal sections of the form. Proceeding to the next tooth space in the mouth, the examiner finds that the maxillary left second tooth space contains a permanent second incisor free of pathosis. This particular observation is given verbally to the clerical assistant as follows: "Lateral incisor, P 3." The assistant records these symbols in the "a" column as is shown in the figure.

With the code well in mind, the symbols given on the examination form may be translated readily into the usual clinical terminology and vice versa. Thus from *fig. 1*, the dental findings for the upper left quadrant of the mouth may be translated further as follows: The maxillary left canine tooth space contains a deciduous canine which is carious (D_4) on the distal surface (3). The next tooth space posteriorly contains a permanent first premolar free of pathosis (P_3). The permanent second premolar occupies the next tooth space and is also free of pathosis (P_3). The maxillary left first permanent molar has caries (P_4) on the occlusal surface (X). The fact that the second and third molars have not erupted is shown by the symbol "0" in the "a" columns of the blocked areas corresponding with these tooth spaces. In like manner, the code symbols recorded for the remaining quadrants of the mouth may be translated into clinical terms.

It is clear that the form and code as presented provide for the description of only a portion of all the observations which may be desired in an epidemiological study of dental caries. Provision for the recording of additional details is made on the lower section of the record form. For example, it was considered desirable to collect information on congenitally missing teeth, on Hutchinsonian teeth, dental abscesses, Vincent's infection, and so on. When such conditions were observed, the dentist-examiner dictated a full description which the clerical assistant wrote into the space labeled "Special notes."

THE PROCESSING PROCEDURE

The processing of the data recorded on the forms consisted of the following steps; the summarization of each individual record form, the preparation of a punch card for each examination, and the mechanical sorting-tabulation of the cards.

Summarization of the individual record forms: In planning the statistical analysis, it became apparent that while material on the individual teeth and tooth surfaces would be required, it would also be necessary to have a general summary of the dental status of each individual subject. The record for an individual should show the total number of teeth present in the mouth, the number of deciduous and permanent teeth with caries, the number filled, and so on. Space for

recording such data is provided by the series of rectangular spaces or "coding boxes" placed on the lower part of the examination form under the heading "Summary" as is shown in *fig. 1*. In the first summary box at the left there is placed the number of deciduous teeth present in the mouth of the individual examined. This number is obtained by counting the number of times "D" appears in the "a" columns of the middle section of the form. The next coding box shows the number of deciduous teeth with active and/or arrested caries. This value is obtained by counting the number of times "D_4" and "D_8" appear. Similarly, a total of 16 summary items is obtained from counts on the detailed record and written into the coding boxes. In sequential order from left to right these are as follows[2]: a. Number of deciduous teeth present in the mouth. b. Number of deciduous teeth affected by caries. c. Number of deciduous tooth surfaces affected by caries. d. Number of filled deciduous teeth. e. Number of filled deciduous tooth surfaces. f. Number of deciduous teeth with one or more pits in which the explorer catches. g. Number of permanent teeth present in the mouth. h. Number of permanent teeth affected by caries. i. Number of permanent tooth surfaces affected by caries. j. Number of filled permanent teeth. k. Number of filled permanent tooth surfaces. l. Number of permanent teeth with one or more pits in which the explorer catches. m. Number of unerupted permanent teeth (including the third molars). n. Number of missing (extracted) permanent teeth. o. Number of teeth (deciduous and permanent) present in the mouth. p. Number of decayed, missing and filled permanent teeth.

Punching of the machine card: The information given on each individual examination form is transferred to a regular 80 column punch card (Holerith). The minor technicalities of this procedure are not essential to the present discussion but it seems desirable to indicate briefly how certain details are handled. The 80 columns of the machine card are distributed as follows: The first 5 columns are used for data on age, sex, gingivitis, occlusion, and so on. The next 56 columns, 2 for each of the 28 tooth spaces in the mouth (excluding the third molars), are used for the details appearing in the "a" and "b"

[2] Data on the third molars are excluded, except as indicated in the code.

columns of the middle section of the record form. Sixteen of the remaining 19 columns are used for the 16 items given in the summary section at the bottom of the form. The last 3 columns on the machine card are reserved for additions to the code.

Little discussion of the transcription of the first 5 columns is required except a statement that a "split-field" multiple punch code is utilized. The 56 columns on the detailed condition of the teeth and tooth surfaces are transferred to the machine cards by direct multiple punching of the symbols appearing in the "a" and "b" columns of the examination record, with the following added proviso: When "P" appears in an "a" column on the record form, the Y or 12th position of the machine card column is punched; when "D" appears, the X or 11th position of the card is punched. The 16 summary items are transcribed according to the following multiple punch code:

0 = 0	Y = 10	X = 20
1 = 1	Y1 = 11	X1 = 21
2 = 2	Y2 = 12	X2 = 22
3 = 3	Y3 = 13	X3 = 23
4 = 4	Y4 = 14	X4 = 24
5 = 5	Y5 = 15	X5 = 25
6 = 6	Y6 = 16	X6 = 26
7 = 7	Y7 = 17	X7 = 27
8 = 8	Y8 = 18	X8 = 28
9 = 9	Y9 = 19	X9 = 29 or more

When the value of any of the summary items is 29 or more, the exact value is written by hand into the appropriate column of the punch card.

In review of the recording and processing methods thus far described, it may be pointed out again that no intermediate coding (except the coding of the 16 summary items) takes place between the recording of the clinical observations by the dentist's clerical assistant and the work of the punch card clerk. In this connection it may be stated also that the dentists experience little difficulty in using the code and that the clerical assistants are able to record the dentist's dictation with a high degree of accuracy. The coding of the 16 summary items

has proved a relatively simple procedure. The transcription of the data given on the examination form to the machine card is accomplished with facility by the punch card clerks.

Tabulation of the data: While it is obvious that the data on the punch cards can be analyzed in many ways, some more or less standardized tabulations are necessary for giving basic details on separate subgroups of the population examined. Two machine forms were prepared for this purpose and are shown as *figs. 2 and 3.* The first of these illustrates the table on which are recorded details on the 28 tooth spaces given in the 56 columns (columns 6 through 61) of the punch card. The second illustration, *fig. 3,* shows the machine table for recording frequency distributions of the 16 summary items given in columns 62 through 77 of the punch card.

It may be noted from *fig. 2* that each tooth space in the mouth is assigned a single horizontal row of spaces and that additional horizontal rows are inserted for totals on the 4 quadrants of the jaws and for the mouth as a whole. Subdivisions of these horizontal rows provide details separately on the teeth and tooth surfaces of the deciduous and permanent dentitions. In the lower right hand corner of this table, space is reserved for recording certain "control" items such as age, sex, school, grade and number of children examined. In order to illustrate the use of this machine table some of the information shown in *fig. 2* will be described. In the lower right hand corner it is indicated that the tabulations contain details on 55 nine year old boys who were attending the Winter School. The horizontal row for the maxillary left canine tooth shows that 47 of the boys have this deciduous tooth present in the mouth. Thirty-one of these teeth are free of pathosis (D_3), 15 show active caries (D_4), and 1 shows arrested caries (D_8). Of these latter 16 (D_4 and D_8) teeth, 1 occlusal surface, 3 buccal surfaces, 2 mesial surfaces and 13 distal surfaces are affected by caries. Two boys have permanent canines in this tooth space, of these one is free of pathosis (P_3) and the other has caries (P_4). Six boys have this tooth space unoccupied because the deciduous tooth has exfoliated and the permanent tooth had as yet not erupted ("0"). Reading from the row of figures marked "Grand Summary" the table shows that 495 deciduous teeth are present in the mouths of the 55 boys. Of these teeth, 227 are free of pathosis,

FIG. 2

247 are affected by active caries, 13 have arrested caries, none are filled and 8 have pits and fissures in which the explorer catches. From

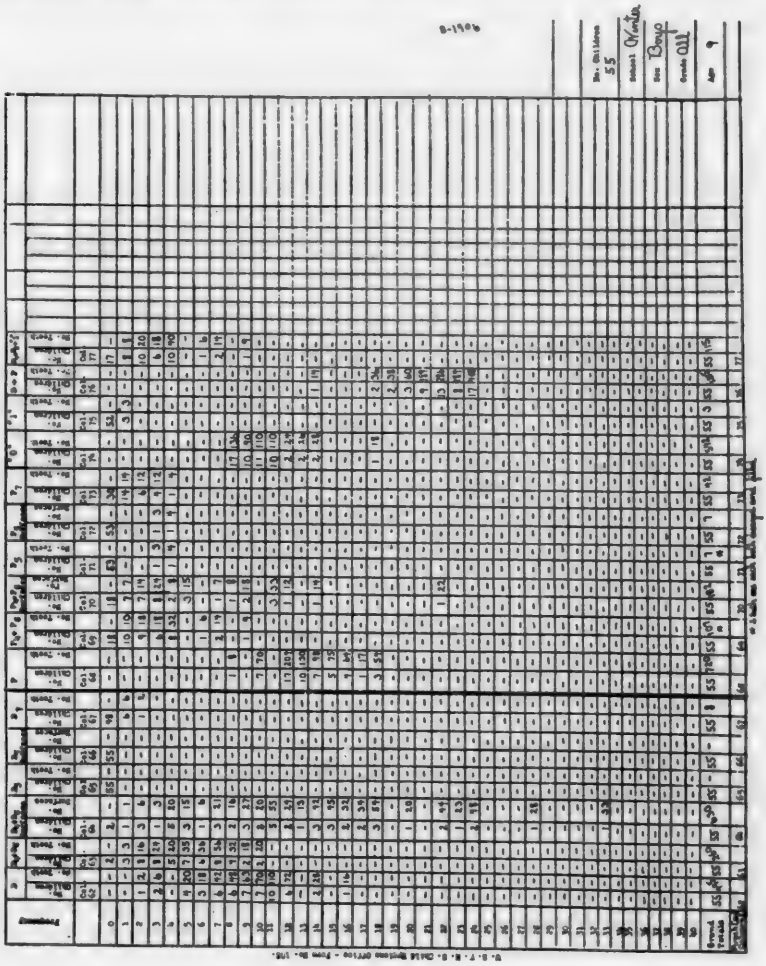

FIG. 3

an inspection of the remainder of the table the reader will observe that a large amount of detailed data is recorded on the individual teeth and tooth surfaces of this particular group of 55 boys.

The machine table illustrated in *fig. 3* is subdivided for entering frequency distributions of the 16 summary items given on the examination forms. The second column of numbers on the left shows, for example, that all of the 55 boys have deciduous teeth in the mouth, that 1 boy has 2 deciduous teeth, 2 boys each have 3, 4 boys each have 5, and so on. In the next column to the right is given the number of deciduous teeth present in all the boys having specified numbers of these teeth present in the mouth. The total at the bottom of this column may be used as a check of the finding shown in *fig. 2* that there are 495 deciduous teeth present in the mouths of the 55 boys. Other columns in *fig. 3* give similar details for each of the 16 summary items.

The material provided on these machine sheets constitute primary tabulations from which the interpretations and analyses of the material may proceed.[3]

SUMMARY

A system for the collection and analysis of dental examination findings is described. This system, now under test for more than 3 years and used for recording and processing nearly 14,000 examinations, has proved generally adequate for studies on the epidemiology of dental caries.

REFERENCES TO LITERATURE

(1) Hyatt, T. P., *J. D. Res.*, 9: 411, 1929.
(2) Klein, Henry and Palmer, C. E., *Pub. Health Reports*, 55: No. 28 (July 12), 1940.

[3] Details of the interpretations developed from these data are given in the series of reports of which the present paper is the tenth. Reference (2) of the appended bibliography contains a full listing of these reports.

INTERNATIONAL ASSOCIATION FOR DENTAL RESEARCH

Proceedings of the Eighteenth General Meeting[1]
Benjamin Franklin Hotel, Philadelphia, Pa.
March 13 and 14, 1940

Compiled by HAMILTON B. G. ROBINSON, *Editor*[2]

Washington University, St. Louis, Mo.

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[1] The sessions of the Research Association preceded, by agreement, those of the Seventeenth Annual Meeting of the American Association of Dental Schools, in the same hotel, March 15–17. The members of each body were welcome at, and participated in, the sessions of both Associations. The chairmen were the President, William J. Gies, Columbia University, and the Vice-president, Wilmer Souder, National Bureau of Standards. The annual informal dinner, served to 98 members and guests, preceded the concluding session, March 14. The Association participated in a joint program with the American Association of Dental Schools, the American Association of Dental Editors and Omicron Kappa Upsilon, sponsored by the American College of Dentists in Baltimore, Md., March 17. This preceded the Dental Centenary Celebration in that city.

[2] The Editor of the Journal is serving, informally, as Editor for the Association. The General Secretary, Edward H. Hatton, has given invaluable aid in preparation of these proceedings.

I. Address of Retiring President

The Work and Functions of the International Association for Dental Research

William J. Gies, Ph.D., Sc.D., LL.D., F.A.C.D., School of Medicine, Columbia University, New York City

At our annual meetings, in recent years, the President has devoted his valedictory address to a subject of general scientific interest; the incoming President has restricted a brief inaugural address to sentiments of appreciation of the honor conferred upon him. A year ago, to facilitate readjustment of these two annual official presentations to broader purposes, the inaugural address included comment on various conditions in the Association's affairs. Last October, while President-elect Kronfeld and I were attending the semi-centennial dental anniversary at the University of Minnesota, we projected a coordinated procedure, for his prospective inaugural address and mine as the retiring President, to attain these general objectives: (*a*) The address of the retiring president to be brief, and devoted chiefly to transactions during his administration; (*b*) the inaugural address to be mainly a discussion of a subject of scientific interest. We believed that this procedure, by providing for timely allusions to the Association's current affairs, would assure greater usefulness for these related addresses, and that future presidents would be inclined to adopt and improve the plan. Dr. Kronfeld's untimely death a month ago, and ensuing uncertainty until tonight regarding the selection of his successor, have required various unexpected departures from our customary procedure.

Uppermost in the thoughts of all of us, day by day in recent months, have been the tragic conditions in the many nations now being devastated, or about to be overwhelmed, by armies under the direction of dictators, whose inspirations appear to be derived from barbarism. Sympathy for our members in nations that have been outraged is deep and abiding. Some of these afflicted members have come to this country, where each of them has been welcomed. This Association is devoted to the advancement of science in the service of humanity—to the promotion of human welfare—to the maintenance of the freedom, and peace, and justice that nurture and sustain all that is finest

and best in civilization. We realize the great dangers that are seriously threatening every peaceful and defenseless nation. Let us, in this country, convert our detestation of war and our contempt for dictators into a resolute purpose to strengthen the resources of the United States and to cooperate, at all times and in every way, for its ample protection, so that our great democracy will continue, in the ways of peace and fortunate development, toward the fulfillment of its social ideals, to assure the greatest possible contentment for each and all who help to maintain it.

In various parts of the world science has ceased to be itself. Under dictatorships it has been degraded into varieties of governmental partisanship. In the United States, there has been no impairment of freedom in scientific work or in its publication. It is a pleasure to call attention to an outstanding illustration of scientific freedom in dentistry. In April, 1938, copies of an "open letter to all investigators, throughout the world in the field of dental caries," were widely distributed and reprinted or abstracted in various journals. This "open letter" invited all concerned to send to the Research Commission of the American Dental Association, for collective publication, "a concise summary of the basic findings of fact which [in the belief of each respondent] warrant the conclusions that . . . represent the essential results and his matured judgment of the outcome of his own study in this field." Last October the American Dental Association issued a volume, entitled "Dental Caries," containing 195 such summaries by as many responsive individual authors or groups of authors in twenty-five countries. In that book each author's findings and opinions were published as presented, without change excepting superficial adjustments to mechanical uniformities for the convenience of the readers. There was no censorship—no removal or modification of any idea or any conclusion to agree with an editor's preference, or a committee's requirement, or an association's demand, or a government's behest. Under these conditions of scientific freedom much was included in the book with which individual observers disagree. Several reviewers of the book published opinions to the effect that some of the expressed ideas on the etiology and on the prevention of caries are "fantastic." If this book had been published by a dental association under a dictatorship, only findings and conclusions agreeable to that dictatorship

would have been included; and no reviewer in such a nation would have been permitted to call anything in the approved volume "fantastic." Fortunately, in this country opinions that are or seem to be "fantastic" may be freely published. Here we act in harmony with this respected opinion of Justice Oliver Wendell Holmes: "The best test of truth is the power of the thought to get itself accepted in the competition of the market." In America, the scientific spirit will assuredly withstand all encroachments of autocracy, intolerance, prejudice, or any other form of restraint upon intellectual freedom and open discussion. It is certain that even under dictatorships Truth will win every long race with Error.

In the inaugural address in 1939, in a discussion of our relations with various organizations, attention was drawn to the fact that "there is a wide gap in the *public relations of dental research.*" It was said that "the public, and also philanthropic sources of funds for widely diversified research in *health* work, have not given to dental research the support it needs in the public interest. . . . The present inertia in public philanthropy, as affecting dental conditions, will probably continue until prospective donors realize not only that dental deficiencies have serious effects on *general health*, from early childhood, but also that means of preventing or more perfectly controlling dental diseases —now urgently needed—await discovery through the agency of intensive and well supported research." It was suggested "that the five active officers be appointed a special committee to endeavor, in collaboration with other dental organizations, to stimulate the interest of philanthropic foundations, and other sources of public funds, in the improved financial support of dental research; the effort of this committee to be general in scope, and conducted to bring support to applications for funds that may arise independently in different quarters, and not to commit the Association to dental research under any particular auspices or in any special relationship." This recommendation was approved. Unfortunately for the execution of this purpose, several events shortly after our general meeting in 1939 suggested that the proposed plan could be promoted more effectively if the collective efforts were delayed for at least a year. These adverse events included (*a*) the publication of a philanthropic foundation's annual report containing some unappreciative comment on dentistry,

which might have seemed to suggest our plan and thus to have weakened its appeal; and (*b*) a purpose by a leading university to seek a large fund for an experiment in dental education and affecting dental research, with which our movement would have conflicted. Accordingly, the proposed joint endeavor was suspended until it can be initiated under favorable conditions, which I hope will develop during the next administration.

The inaugural address, in 1939, contained the statement that the "Association's constitution, which was adopted in 1921, has never been formally amended, although occasional decisions, in extension of its provisions, have had the force of amendments. By-laws have not been added, although various regulations and customs have the effect of by-laws." It was suggested, in the same address, that recent developments "increase the need for a deliberate re-study of our constitutional system, and for an effort to bring the constitution and by-laws into working accord with the Association's experience and development." The five chief officers in 1939–40 were appointed a special committee, with Vice-president Souder as Chairman, to perform this important function. In accordance with these proposals, the said committee, after earnest cooperative studies for several months, presented a rewritten constitution as a proposed *amendment by substitution* [pages 339–344], which is now "on the table," for an ad-interim vote and a report thereon at the general meeting next March. The proposed new constitution, while continuing the original structural conditions, includes provisions that bring the following important matters, and related subsidiary situations, into accord with the Association's stated preferences: (*a*) Organization and coordination of "*groups*" representing specified portions of dental science. (*b*) Definite provisions relating to officers, including Editor and Trustees, and combination of the offices of Secretary and Treasurer. (*c*) Management of the *Journal of Dental Research* and its Endowment Fund. (*d*) By-laws—none heretofore adopted—that would convert into standing provisions various "rules and regulations" of the Council. The provision relating to dues remains unchanged—"not to exceed $5.00," but in practice not more than $1.00. The Committee believes that the constitution as thus rewritten—and the associated by-laws—would effectively stabilize the affairs of the Association, on its present

democratic basis and in harmony with its precedents and prospective requirements, until further developments suggest amendments.

The inaugural address in 1939 included comment on the movement in favor of the organization of "groups" within the Association, to further the advancement of particular phases of dental science. In conformity with plans developed during the year, the "Dental Materials Group"—the first to be organized—held its initial scientific meeting last evening, and is now on the way to successful development. In the arrangement of the programs for the simultaneous evening sessions yesterday of the Association and the Materials Group, the Program Committee prevented conflict of interests by devoting the Association's session to subjects as remotely related to "materials studies" as possible. The successful conduct of these two sessions on the same evening suggests that the accumulating pressure on the program of the Association's general meetings may be prevented from becoming excessive—in a two-day allowance for the whole series—by transferring portions of the increasing number of offerings to simultaneous sessions on dissimilar "group subjects."

During the past year two new sections have been organized: one in Palestine; the other in Houston, Texas. The five colleagues in Denmark who were elected to membership at this session have indicated readiness to organize a section in Copenhagen. These evidences of further growth are very gratifying. Unfortunately, for the first time in the history of the Association, a section has been discontinued because, in the belief of its sole resident survivor, there is no prospect of further local interest in its development. I refer to the New Haven Section, which was organized in 1930, shortly after the "Yale experiment" for the improvement of dental education and of dentistry under medical direction had been initiated—and generally accepted as an important constructive influence in dental science and in medico-dental relationships. The influence of this experiment has not been strong enough to maintain the early promise, nor to assure sufficient activity and personnel in dental research at Yale to support a section of minimum size in New Haven, Conn.

The welfare of the *Journal of Dental Research* is a matter of deep concern for all of us. Its management is in "strong and capable hands." Its development has been retarded by depressing economic

influences, owing to which its circulation has been decreasing, and it contains little more per volume than half the number of pages published eight years ago. Special rather than routine efforts are required to make the *Journal* as useful as it should become. The need for increased financial support is widely appreciated, as is shown by the growing interest in the development of the Endowment Fund. Some of the members of the Board of Editors have been urging that the subscription price for the *Journal* be added to the Association's annual dues, to force all of the members to "pay for the *Journal*." I earnestly recommend that this device be rejected whenever it may be proposed, and that the ingenuities of effective persuasion be substituted. Most of the active members of the Association are relatively young, have inadequate incomes, and do their work in institutions where the libraries contain the *Journal of Dental Research*. The vitality of the Association is dependent upon the interest and activity of the younger members. Others should carry the Association's chief financial loads. The affairs of the Association should be made particularly helpful and encouraging for all of the younger members. To *force* these members to provide, for the *Journal*, any portion of the financial support that should and could be obtained *voluntarily* from others would be inconsiderate to say the least, and also would disregard the constructive purposes which for twenty years have kept the Association's annual dues at the nominal amount of one dollar. The *Journal* was presented to the Association as the controlling organization that would most naturally deserve and effectively obtain, chiefly from sources outside of the Association, the financial support required to maintain the *Journal* as a special agency for the advancement of research in dentistry. Many subscription possibilities have not yet been explored. Adequate effort, by or under the direction of the Circulation Manager, should assure—on a voluntary basis—the financial support required to increase the *Journal's* scientific usefulness and influence.

At a meeting of the American College of Dentists in Baltimore next Sunday, as a preliminary to the Dental Centenary Celebration, I shall conclude a paper on "research as an important factor in dental progress" with this appeal to dental *practitioners* for support of the *Journal of Dental Research:*

"The need for investigation in every phase of dentistry is so obvious, and in many aspects is so urgent, that it is impossible to overstate the importance of increased activity in, and support for, dental research. Thorough and comprehensive research cannot be conducted without expense in time and materials. As a rule, effective research requires practically whole-time attention and reasonable remuneration. Research fellowships and grants-in-aid for research, for the assistance of young workers especially, are multiplying; investigations by members of dental faculties are increasing in number and importance; and interest in collaborative inquiries in dentistry, in universities having medical and dental schools, is growing. The proceedings of the International Association for Dental Research, since its establishment in 1920, present a succession of earnest endeavors and notable achievements, and a promise of cumulative usefulness.

"A fundamental difficulty in the promotion of research is the fact that *those who conduct it cannot assume, or be given any assurance, that their efforts will be fruitful.* Dental research is never a 'sure thing.' Researchers must proceed at their own risk, so far as satisfaction in achievement is concerned. They understand that years of effort may yield only experience and failure. These are not very attractive prospects, and they tend to discourage effort. Therefore workers in dental research deserve the hearty support of dental practitioners, especially the encouragement afforded by evidences of appreciation of efforts in research. 'Research men' in dentistry also need a respected special medium of publication in which their studies can be recorded permanently under conditions that compare favorably with those for investigators in other fields. The *Journal of Dental Research* (now being published by the International Association for Dental Research)—which since 1919 has been meeting this need in dentistry and should be enlarged as dental research increases—merits the active support of every dentist who wishes to help and to encourage the workers who are giving their best efforts to the furtherance of dental science. Continuous subscriptions for it, by dental practitioners, may reasonably be based wholly, regardless of direct value to the subscriber, on a purpose to support the promotion of dental research—*'to give rather than to receive.'* For those who are not actively interested in ways and means of research, many of the records in research journals, owing to their technical character and the details that must be included to enable others to test the described results, are neither entertaining nor interesting. But, fortunately, efforts by dental practitioners to understand such records in the *Journal of Dental Research* accord with the progressive educational spirit of the times; can do no harm to the reader; and give him useful graduate instruction. Support for the *Journal of Dental Research* is the kind of assistance and encouragement that dentists should cheerfully assure for those who are pushing forward the boundaries of dental knowledge, and who are thus steadily preparing the way for continual progress for the dental profession."

The executive affairs of the Association, during the year, have been conducted very efficiently. It has been our custom from the beginning to regard the General Secretary as the chief executive officer and the President as, in effect, only an honorary advisor. I have had these experiences in both offices and feel that the custom is excellent. Secretary Hatton has performed his duties industriously, earnestly, and with great ability—and democratically. The welfare of the Association will always depend largely on the faithful and competent per-

formance of the duties of the office of General Secretary. I recommend that those of the successive secretaries who perform their duties well be retained in the office of Secretary as long as they can be persuaded to continue. If an increase in the annual dues were desirable, it would seem to be more appropriate to use it to provide clerical assistance for the General Secretary than to encourage the Publication Committee and its assistants to weaken in their constructive endeavors to quicken interest in the *Journal*, when and where ingenious efforts to that end may be required and would be successful.

The Association's executive proceedings, as conducted at our general meetings, are open to the constructive criticism that members of of the Council who may be reasonably expected to attend the meetings of the Council are often conspicuous by their absence. This statement applies not only to members of the Council in the United States who do not attend the general meetings of the Association, but also to members of the Council who, although present at the general meetings, do not participate in the sessions of the Council. Our Association has been conducted as a strictly democratic organization. The Council, consisting of representatives of the sections, is the chief executive body. Democratic procedures cannot be maintained unless they receive the devoted attention of those who have been elected to represent the sections. The welfare of the Association would be promoted by the invariable election, to membership in the Council, of active members who would assuredly endeavor to give their representative functions faithful attention.

One of the outstanding impressions in my cumulative personal observations, at each of the general meetings of the Association since its organization in 1920, is the steady growth in the scientific quality of the presentations, and in the number of offerings for the program. As one of the founders also of two other leading scientific societies—the Society for Experimental Biology and Medicine (1903), and the American Society of Biological Chemists (1906)—I have had ample opportunity to compare intimately their evolution with that of our Association. The rates of growth, both qualitatively and quantitatively, have been so closely analogous that it may be truthfully said that our Association embodies the spirit and ability which have made these two older societies outstandingly effective in their promotion

of science in medicine and biology, and in biological chemistry. I am confident that if we continue earnestly to exemplify democratic purposes in procedure, and to give the greatest possible encouragement to the younger workers in the field of dental research, our Association will successfully maintain its growth and influence as the most useful scientific organization in dentistry.

Since the establishment of our Association, nearly twenty years ago, I have been intimately associated with its development—almost continuously in official relationships. In imagination, I see the Association growing steadily in size, and vigor, and usefulness, annually rejuvenated by accretions of young, able, and aspiring workers in dental research. I wish I might annually be one of them, to live again, and recurrently renew, the past years of constructive activity in our endeavors together. But the passing years are inexorable in what they exact from each of us; and, near the milestone that marks three score and ten, I must bow to the inevitable. In returning to the ranks, and officially bidding you farewell, I thank you earnestly and heartily for the many special opportunities you have given me to work with you for the advancement of science in dentistry. I now have the great honor to welcome to the presidency of this Association our distinguished co-worker, Dr. Wilmer Souder, of the National Bureau of Standards.

II. Rudolf Kronfeld, B.S., M.D., D.D.S.

Edgar D. Coolidge, D.D.S., Loyola University, Chicago, Ill.

The sad necessity of preparing an article on the life of Rudolf Kronfeld for presention at the time and place at which he was to have been inducted into the Presidency of the International Association for Dental Research has been somewhat tempered by the revelation of interests, activities and accomplishments of an unusual character. Loved and esteemed by all who knew him, popular from childhood to the closing of his career, cut off in the early morn of a virile and productive life, we can only wonder what might have been had he not been, as Dr. Hillenbrand so well stated: "The victim of a relentless malady that made futile all the powers of the sciences to which he had so fruitfully dedicated his talents—The

brilliant promise and achievement of his career were stopped in mid-flight, but he would have been the last to decry the value of the scientific research which as yet could not make the priceless gift of remedy and cure to him."[1]

Rudolf Kronfeld was born in Vienna, Austria, December 10, 1901. His father, who is still living, is a dentist and was active in practice in Vienna for about 40 years before moving to London, England in 1939. Rudolf's mother died when he was very young and he and his younger brother, Robert, were guided through their childhood years by their step-mother. The boys and their father were always close confidants. As the boys grew up, the father and sons frequented the woods, the mountains, the river and used every opportunity to enjoy the freedom of the great out-of-doors. At 10 years of age Rudolf had acquired an extensive knowledge of botany and in later years became an authority in the identification of flowers, plants and trees about Vienna. He was deeply interested in biology as a boy and frequently kept reptiles and small animals in cages over winter for biologic study. He was always engaged in some outdoor activity and was among the leaders in mountain climbing, water sports and skiing. Dr. Orban speaks of his interest in sports as follows: "He was a very fine sportsman and winner of many trophies and prizes. He frequently left Vienna on week-end trips leaving on Saturday afternoon about 6 o'clock and, arriving at the foot of Snow Mountain (Schneeberg) at 9 P.M., he climbed about 6000 feet with his skis on his back reaching the peak about midnight. He spent about 5 hours in sleep in a cabin and then arose and spent the entire Sunday on his skis returning to the city in the late evening. He was also a member of one of Vienna's regatta clubs and was a fine boatsman. His team won many trophies in competition with other teams. He could take the hardships of sports very well."[2]

After graduating from a Vienna Gymnasium he entered the University of Vienna from which he received the degree of Doctor of Medicine in 1926. While a student in medicine, Dr. Kronfeld busied himself in the Dental Institute of the University and became inter

[1] Harold Hillenbrand, Editorial, *Bul. Chicago D. Soc.*, 20: 13, 1940.

[2] B. Orban, former Associate in the Research Laboratory of B. Gottlieb, University of Vienna. Correspondence.

ested in research. He became an assistant in the Dental Institute upon graduation and devoted part of his time to teaching and part to research. In teaching a group of graduate dental students from Italy he was soon able to converse with them in their own language. He had learned to speak the French language in his home and had acquired a knowledge of English while he was a student in the University.

During the College year of 1926–27, Dr. Kronfeld became attached to the Research laboratory of Dr. Bernhard Gottlieb in the Dental Institute and gave up his teaching and other connections to devote his entire time to the laboratory. He worked with Drs. Gottlieb and Orban until the following summer of 1927. From 1926 to 1929 Dr. Kronfeld carried on extensive research under the guidance of Dr. Gottlieb. Ten publications of his studies and research appeared in the German literature during the period he was in Gottlieb's laboratory.

In May, 1929, Dr. Kronfeld came to Chicago to engage in research and teaching at the Chicago College of Dental Surgery, succeeding Dr. Orban as Director of the Research Laboratory. Rapidly adjusting himself to his new surroundings, he soon won the confidence and respect of all who were associated with him. The following statement from his technician and secretary, Maurine Willman Müller, expresses in a few words the high esteem in which his associates held him,—"It would probably be impossible to work with or for a more considerate person than was Dr. Kronfeld. My work as secretary and technician was naturally exacting and complicated, but Dr. Kronfeld always made it as easy as possible by his even temper and genuine understanding. He himself knew the essentials of histologic technic, which enabled him to give me sympathetic and helpful advice on many problems, especially in the first couple years of our association. His death is more of a shock to me than I have words to tell. Dental research has surely lost one of its most competent workers."[3]

Upon his arrival in Chicago Dr. Kronfeld became attached to the Young Men's Christian Association of Chicago. He became active

[3] Maurine Willman Müller, Technician and secretary to Dr. Kronfeld. Correspondence.

in the work of the Association which interest he maintained until his death.

Although Dr. Kronfeld was intensely devoted to his duties he had the love of nature so deeply imbedded in his life that he soon began seeking the field, the forest and the glen at every opportunity. He seldom traveled by the beaten path but sought out the beauty spots on every journey he took. He frequented the sand dunes of Indiana along the southern extremity of Lake Michigan and spent most of his leisure time tramping over hill and dale in search of rare flowers, trees or wild life. Later on he established a home in the dunes which perhaps served as a substitute for his cabin in the Austrian mountains in which he had so often enjoyed the wholesome out-of-door life. Dr. Celia Rich, one of his close friends who had often enjoyed the hospitality of his home writes as follows: "He never tired of his gardening at his charming home which he and his lovely wife had established on the Indiana Dunes near Lake Michigan and no gift from a friend was more valued than some wild or beautiful plant which he could naturalize there."[4]

Soon after his arrival in Chicago, Dr. Kronfeld entered upon the study of dentistry along with his duties at the College and graduated in dentistry with the class of 1933. He entered the College of Liberal Arts of Loyola University and received the degree of Bachelor of Science in 1935. For his outstanding work in the Dental School he was elected to membership of the honor fraternity, Omicron Kappa Upsilon, and for scholastic excellence in the College of Liberal Arts, was made a member of the Blue Key fraternity. He was also a member of the Delta Sigma Delta dental fraternity.

Although he was a stranger in a strange land Dr. Kronfeld made rapid progress in establishing himself in the field of dental research and as a speaker upon programs of dental society meetings. During the first few years his associates frequently introduced him to others, but very soon he had more acquaintances and could address more confreres by name than most of those who had introduced him in his early years. His memory of faces and names was most unusual. He seldom had to ask the name of a person a second time.

[4] Celia Rich, Nashville, Tennessee. Correspondence.

As a teacher, Dr. Kronfeld was highly esteemed by both faculty and students. He was always courteous, considerate and helpful in every way. He had the unusual ability of making a difficult subject easy to understand and fascinating to study. A student speaks of him as follows: "He never raised his voice in criticism of another and never refused to answer any question no matter how trivial. If he did not know the answer he always said so and went out of his way to find the answer. He knew his own short-comings and was tolerant of others. His lectures were always orderly and interesting. Simplicity was always the characteristic of his teaching that made it so effective and so popular."[5]

Dr. Kronfeld was an active member of many professional organizations to which he generously contributed of his knowledge and time. He regularly attended meetings of medical groups as well as dental. He was a member of the Chicago Medical Society, Illinois Medical Society, American Medical Society, Chicago Pathological Society and American Association for the Advancement of Science, the American Dental Association, the Illinois State Dental Society, the Chicago Dental Society, the International Dental Federation and the Odontographic Society of Chicago. He was granted honorary membership in several other dental organizations. He was serving as President of the American Academy of Periodontology for the year 1939–40, which organization had honored him by making him a Fellow of the Academy in 1937. He was one of the charter members of the Vienna section of the International Association for Dental Research. Dr. Kronfeld became a member of the Chicago section in 1929 and at once took a very active part in every meeting of the Chicago section as well as in the annual meetings of the general body each year. He served as secretary of the Chicago section during 1930–31, and as President during 1931–32. In 1937 he was elected Vice-President and in 1938 President-elect of the general body and was to have been inaugurated as President at this meeting in Philadelphia.

Dental literature has been greatly enriched by the writings of Rudolf Kronfeld. His publications include 19 papers in German literature, 1 of which was in collaboration with Rudolf Ullik, 43 in

[5] Robert G. Herthneck, Senior Student, Chicago College of Dental Surgery, Dental School of Loyola University, Chicago.

American dental journals, of which 2 were in collaboration with Isaac Schour, 1 with W. H. G. Logan, 1 with Emil Mueller and 1 with F. J. Barker, and 1 paper published in England. In addition to this generous contribution of formal papers many addresses were made before dental society meetings where no publication of his paper followed, and he had prepared and displayed about 30 scientific exhibits at dental meetings during the 10½ years that he had lived in America. Two dental text-books have been published, one, which is now in its second edition, being regarded by his confreres as his outstanding contribution. He contributed 1 chapter to each of 3 other books, 1 of which is still in the publisher's hands. His work as an author is highly regarded by his publishers.

In an appraisal of the research and published record of the work of Rudolf Kronfeld, Dr. Schour has made the following comment: "Each investigator selects his problems and research program according to his temperament and standards of usefulness. Kronfeld was motivated by a strong desire to place clinical dentistry on a scientific basis, and was eminently successful in attaining this objective. His research and publications centered on those histologic and histopathologic aspects of problems that confront the dentist in his every-day practice, and were equally valuable in dental education and dental research.

"His textbook on Histopathology of the Teeth and their Surrounding Tissues which passed through two editions will remain a leader in its field for many years. To the dental profession Kronfeld still lives through his published works; and to the many who enjoyed his personal friendship and cooperation his kind and gentle personality will remain a permanent ennobling influence."[6]

It had been a cherished desire of Dr. Kronfeld to establish a dental practice. He wished to be able to put some of his vast information into practical use. It had always been his aim and purpose to translate the findings of the research laboratory into actual practice. I shall never forget the thrill of pleasure that he manifested when he and those working under him discovered something in the study of the laboratory material that might shed light on some important

[6] Isaac Schour, Professor of Histology, University of Illinois, College of Dentistry, Chicago. Correspondence.

subject or perhaps would be of practical benefit to those practicing dentistry. In 1937 he opened an office for the practice of dentistry during a part of his time. He exhibited a deep interest and enthusiasm in his practice. His associate in the same suite of offices, Dr. Dahlberg, has the following comment to make about Kronfeld in the practice of dentistry:—

"I was associated with Dr. Rudolf Kronfeld for over 3 years in the practice of dentistry and, as this time passed, I became more fully aware of his complete concept of dental and oral problems. On several occasions he told me of the satisfaction he derived from practicing dentistry himself. He had as a result the practitioner's as well as the laboratory worker's point of view. He loved his work."[7]

In the winter of 1938–39, Dr. Kronfeld was overtaken by a fatal illness that began to manifest itself in a progressive manner. He realized that this disturbance would soon make him a helpless invalid. To one who had enjoyed such an athletic youth such a prospect could not be endured. Anticipating his death he had requested that his body be cremated and he designated one of his favorite spots in the Indiana sand dunes on the southern shore of Lake Michigan where he wished to have his ashes buried. He never complained of his condition nor even spoke of it to his most intimate friends and associates. He carried his burden alone. Only Mrs. Kronfeld and his physicians knew the dark prospect before him. He passed away in his research laboratory on February 13, 1940, surrounded by his library, his histologic material and his work in progress for the coming season.

He is survived by his widow, Margaret North Kronfeld, his parents, Robert and Valerie Kronfeld, of London and his brother Robert, internationally known glider and flying instructor of Oxford, England.

Although in close association with Dr. Kronfeld one could not fully understand nor appreciate in life the unusual character and ability of this man. It could only be revealed in compiling the records of his interests and his achievements together with the statements of his associates and his friends. He was a man with many interests but was always interested in others and he never seemed too busy to

[7] Albert A. Dahlberg, 122 South Michigan, Chicago. Correspondence.

give generously of his time. One of his associates and assistants, Miss Carolyn Hammond, has nicely expressed these characteristics in a statement relative to her association with him.—"During my five years' association with Dr. Kronfeld I came to appreciate that he was a most unique combination of scientist and humanitarian. His scientific ability is internationally known. His wide and varied knowledge, his consideration of others, his keen sense of humor, his enthusiasm, his interest in people as individuals, all contributed to make working with him a very real pleasure."[8]

Not only was Dr. Kronfeld generous with his time but was tolerant and lenient in his estimate of others as is ably expressed by Dr. Rich.—

"His loyalty to his friends was only exceeded by his enthusiasm for his work and it was remarkable that with his critical mind in all scientific matters he should have been so charitable in evaluating his friends. We never felt that we were being appraised according to his intellectual standards; instead he accepted us and loved us just as we were. In fact, Rudolf Kronfeld's criticism was never bitter, and it was never personal.

"Like all of the truly great he was one of the simplest of men. His pleasures were wholesome. He had a great love for travel and one of the tragedies of his untimely death was that he had looked forward with such eagerness to an air-plane trip to California in the spring, on a lecture tour, when he was planning to make many stops enroute for sightseeing."[9]

We leave the narrative here with its forward look to his plans for future work to be done, interwoven with his deep love and enjoyment of nature that characterized his entire life. His face will be greatly missed at our gatherings but his work will be a lasting monument to his memory.

The list of published and unpublished works of Rudolf Kronfeld numbering 66 published papers, 4 unpublished papers, 2 text-books and contributions to 3 other text-books are appended to this article. In addition he published 8 reports by abstract only.

[8] Carolyn Hammond, Member of Staff of the Foundation for Dental Research.
[9] Celia Rich, Nashville, Tennessee. Correspondence.

RUDOLF KRONFELD: PUBLICATIONS

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4. Is There a Continuous Eruption of Teeth in Wild Animals? (German), (with Rudolf Ullik.) *Ztschr. f. Stom.*, **26:** 84, 1928.
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8. Cementum and Sharpey's Fibres (German), *Ztschr. f. Stom.*, **26:** 714, 1928.
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28. The Resorption of the Roots of Deciduous Teeth, *D. Cosmos*, **34:** 103, 1932.
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30. Unusual Cysts of the Jaws, *Ill. D. J.*, **2:** 345, 1932.

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68. Traumatic Changes in the Periodontal Tissues of Deciduous Teeth (with Josef Weinmann). To be published in the *J. D. Res.*
69. Metastatic Adenocarcinoma in the Bone of a Lower Jaw (with Josef Weinmann), *Arch. Path*, **29**: 683, 1940.

B. Books

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2. *Tissue Changes Incident to Orthodontic Tooth Movement* in *Practical Orthodontia*, by Martin Dewey and G. M. Anderson (St. Louis, G. V. Mosby: 1935).
3. Collaborator on chapters on Pathology and Oral Medicine in *A Course of Study in Dentistry*, Report of Curriculum Survey Committee of the American Association of Dental Schools, 1935.
4. *Dental Histology and Comparative Dental Anatomy* (Philadelphia, Lea & Febiger: 1937).
5. *Histopathology of the Teeth and Their Surrounding Structures.* 2nd Ed. (Philadelphia, Lea & Febiger: 1939).
6. *Dental Histology with Reference to Operative Dentistry* in *American Textbook of Operative Dentistry.* Edited by Marcus L. Ward, 7th Ed. (Philadelphia, Lea & Febiger) (in press).

III. Inaugural Address

Wilmer Souder, Ph.D., National Bureau of Standards, Washington, D. C.

You have bestowed upon me a high honor for which I shall endeavor to show grateful appreciation. My reputation has, I fear, outrun my achievements. I am not unmindful of those associates who have cooperated in a 20 year program of dental research and whose years of labor have been instrumental in bringing to me this honor. Among those most actively associated with the work I must mention: C. G. Peters, R. L. Coleman, N. O. Taylor, G. C. Paffenbarger, W. T. Sweeney, and the late Aaron Isaacs.

No one individual can hope to match the service rendered by our retiring President, Dr. Gies. There will undoubtedly be a slowing up in our rate of advancement. However, with the benefit of his

counsel this retardation should be temporary, only. The fact that he willingly entrusts to us the responsibility and care for the welfare of this Association, a favorite child of his, implies that he has confidence in our ability to assume the obligation and to meet successfully, the opportunity.

Many of you know that during the last 20 years my services for the Government have been divided. This division is approximately: 50 per cent dental research and 50 per cent criminal investigations. Some of the things which we have discovered in the dental research field might permit me to revise the figure to a more nearly accurate value of 75 per cent criminal investigations and 25 per cent forward-looking dental research. With a dental profession highly susceptible to exploitation through advertisements and keen sales methods we have seen the profession pick a shrinking dental amalgam alloy when offered for sale at twice the price of a safe alloy. We have discovered manufacturers of high quality products apparently forced to supply inferior quality items to meet competition from unscrupulous producers of cheap merchandise. We are regularly offered casting machines, base metal alloys and similar new items which, according to unproven claims, will solve all our difficulties in making dental restorations.

Dental caries has from a personal, financial and scientific point of view commanded my attention for more than 40 years and only recently has our advertising literature been free of claims that this affliction might have been escaped by the use of a magic dentifrice, a special diet or some other profit-taking scheme. Today I find myself equally susceptible to arguments that caries is caused by (a) nutritional defects, (b) bacterial infection, or (c) chemical solution. Perhaps there is truth in all three arguments.

These confused situations have not developed a cynical attitude. Rather they have created a determination to move carefully and safely. A vestige of early religious training persists and inspires confidence that right will eventually prevail. Fortunately as researches progress exploitations retrogress.

As the representative of your Association for the next year I am expected, if correctly informed, to be of assistance to the members

and to coordinate the interests of the Association. This I shall endeavor to do during the ensuing year.

The dangers of creating resentments make it difficult to offer suggestions. However, if I address my suggestions to the younger members of the Association I am sure they will accept them in the spirit in which they are offered.

My experiences in conducting researches make me bold to offer the following general suggestion. There are three possible outcomes to research problems: First, the data may confirm the assumptions set up; Second, the data may contradict the assumptions, and Third, the data may not be conclusive either as supporting or as denying the assumptions. Frequently the data are so technical that the observer alone is capable of evaluating them. In this position of high responsibility the observer must be fair to himself and to the profession which he serves.

The International Association for Dental Research is a well balanced organization and is eminently qualified to serve its membership. To those in honest doubt about the significance of data, we extend a hearty welcome and promise you our best counsel to aid you in making a proper interpretation of your data or in planning further researches which will develop the unique conclusion.

Upon this hurriedly prepared platform and inadequately stated pledge I ask your support during the year 1940.

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V. First Session: Morning, March 13; Abstracts 1–10

1. Action of gastric and salivary mucin on phagocytosis. *Ruth Tunnicliff, A.B., M.D., Foundation for Dental Research of the Chicago College of Dental Surgery, Chicago, Ill.* Gastric and salivary mucin produce a covering on bacteria preventing their staining vitally and inhibiting phagocytosis. Staphylococci suspended in gastric mucin begin to multiply 1 hour after intraperitoneal injection into mice, but their phagocytosis is either negligible or absent until 2 hours later when their number has increased enormously; but only a part are engulfed by leukocytes. Mice receiving staphylococci and mucin die 24 hours after injection. Mice receiving intraperitoneally staphylococci in salt solution show some multiplication of cocci and a fair amount of phagocytosis at the end of 1 and 3 hours with an increase in number in 24 hours, but fewer than in mice injected with staphylococci and mucin. Mice injected with staphylococci in salt solution recover. Vitally stained mucoid material from mice injected with mucin and staphylococci shows unstained, mucin-coated cocci as long as 3 hours after injection. Only stained cocci uncoated with mucin are taken up by the polymorphonuclear leukocytes. The cocci are stained in the peritoneal fluid of a mouse injected with staphylococci in salt solution. These experiments indicate that mucin, by coating organisms, prevents their phagocytosis until they can increase in number and produce death of the animal. (To be published in *J. Infectious Dis.*)

2. Antibacterial effect of saliva on tubercle bacilli. *Frank Kanter, D.D.S., and J. L. T. Appleton, D.D.S., Sc.D., School of Den-*

tistry, University of Pennsylvania, Philadelphia, Pa. One part of a suspension of human tubercle bacilli in Ringer's was added to 5 parts of (a) Ringer's, (b) *aq. dest.*, and (c) centrifuged saliva. Samples were immediately inoculated upon Corper's medium (*J. A. M. A.* **91:** 371, 1928). Tubercle bacilli developed from Ringer's and from *aq. dest.*, but not from saliva sample. Saliva, filtered through Jena sintered glass filter G 5/3, and saliva, heated at 56°C. for 30 minutes, likewise inhibit growth of tubercle bacilli. Above observations hold for salivas of 4 individuals, for none of whom was there history of clinically active tuberculosis. Two reacted strongly, both locally and systemically, to i.c. injection of 0.1 mg. Old Tuberculin. Another was a non-reactor: and chest radiographs of fourth were negative. Centrifuged saliva suspension of tubercle bacilli, injected subcutaneously into guinea-pigs, immediately after mixing (2 animals) and after 2 hours' incubation at 37° (2 animals), produced tuberculosis. Filtered, centrifuged saliva suspensions of tubercle bacilli, injected subcutaneously into guinea-pigs immediately after mixing (3 animals) and after 2 hours' incubation at 37° (5 animals), produced tuberculosis. The inocula were not greater than, and in most cases probably less than, inocula used in *in vitro* tests. Facts, summarized below, may in part account for rarity of tuberculous lesions of oral mucosa. 1. Centrifuged saliva of some persons without tuberculosis inhibits growth of tubercle bacilli on Corper's medium. 2. This inhibition is not due (a) to bacteria of saliva (although rôle of filtrable products of bacterial metabolism was not eliminated), (b) to complement-amboceptor mechanism, or (c) to hypotonicity of saliva. 3. This inhibition is manifested with centrifuged saliva, either filtered or unfiltered, which has been diluted with Ringer's solution (1 part saliva, 4 parts Ringer's). 4. Action of saliva, demonstrable *in vitro*, is not bactericidal, but bacteriostatic and does not render tubercle bacillus avirulent.

3. STUDY OF THE MECHANISM OF INHIBITION OF DENTAL CARIES BY FLUORINE. *Virgil D. Cheyne, A.B., D.D.S., School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.* The inhibition of dental caries by fluorine has been demonstrated in 3 ways: 1. decrease in caries incidence in endemic areas; 2. higher fluorine content of sound enamel than carious; 3. reduction of experimental dental

caries in rats by feeding fluorine after teeth are fully formed. Theories on action of fluorine are: 1. reduction of acid production by oral bacteria; 2. reduction in solubility of fluorosed dental tissues. Further, "Is a constant supply necessary, either from an ingested source or through the saliva?" No reports have appeared describing caries frequency in humans reared under influence of continual ingestion of fluorine and later transposed to a fluorine-free district, i.e., durability of acquired inhibition and effect of stored or circulating fluoride in the body has not been evaluated. In an analogous study made upon rats mottled teeth were produced by feeding mother 600 p.p.m. of fluorine during pregnancy and lactation and young 300 p.p.m. until weaning (dosage calculated on basis of body weight and probable food consumption). Desalivated animals (*J. D. Res.*, **18:** 457, 1939) eliminated saliva as a possible vehicle for systemic fluorine and isolated locally incorporated fluorine in tooth tissue for study. Statistical weighing of results tends to confirm assumption that saliva is of vast importance, especially as it acts to transport caries-inhibiting factor, because high fluorine content of mottled tooth structure seems to offer little resistance to decalcification in xerostomia. Continuous saturation of food and bacteria around tooth is necessary.

4. PRELIMINARY REPORT ON THE EFFECT OF FLUORINE ON RACHITIC RATS. *Sidney B. Finn, A.B., D.M.D., and Kenneth Morgareige, Ph.D., School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.* Two experiments in which 21 day rats were fed rachitogenic diets with and without 300 p.p.m. added fluorine, showed significant differences. Fluorine decreased the severity of rickets as evidenced by radiographs and life span. Radiographically those rats receiving fluorine showed a much greater overall density of bone and a narrower zone of hypertrophied metaphyseal cartilage than those not receiving fluorine. The life span was increased from 43 days to 59 days, when these rats were sacrificed. From these 2 preliminary experiments the question arises as to the possibility that fluorine aids in the conservation of body phosphorus. Whether this action is merely passive, resulting from the decreased solubility of fluor-phosphates or a substitution of fluorine for phosphorus, or whether the fluorine content of the tissues has a definite vital function and hence is a necessary trace element certainly deserves reconsideration in the light of this newly presented evidence.

5. THE MEASUREMENT OF THE ABSORPTION OF FLUORIDES USING A RADIOACTIVE ISOTOPE AS AN INDICATOR. *H. C. Hodge, Ph.D., J. F. Volker, D.D.S., H. J. Wilson, A.B., S. N. Voorhis, Ph.D., School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.* Calcium phosphates (e.g. bone) are known to take up fluorides rapidly from even very dilute solutions. The mechanism of this action has never been demonstrated. To test whether fluorides are adsorbed, powdered samples of enamel and of dentin were exposed, at constant temperature for a given time, to various dilutions of sodium fluoride containing known amounts of radioactive fluorine. The samples were washed and then dissolved in dilute hydrochloric acid. By the use of the Geiger-Müller counter, the amount of fluorine taken up by the enamel or the dentin was determined. When the logarithm of the mgm. of fluorine taken up by a gram of tooth tissue was plotted against the logarithm of the concentration of fluoride remaining in solution at equilibrium, straight lines were found for enamel and for dentin. This satisfies the criterion for adsorption as given by the Freundlich adsorption isotherm equation. Consequently powdered enamel and dentin are shown to take up fluorides by surface reaction.

6. CHEMICAL CHANGES IN ORGANIC MATRIX IN DENTAL CARIES. *Martin Deakins, M.S., D.D.S., School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.* There is a slight absolute loss of organic matrix in "early" stages of caries of dentin and a decided loss in "late" stages. This becomes apparent only when determinations are expressed in mgm. per unit volume of tissue. Decalcified, non-carious and carious matrices contain an average of 17.06 per cent and 15.55 per cent of nitrogen, respectively, a relative loss in caries of 8.85 per cent. The carbon content of non-carious matrix is very constant, the average being 50.47 per cent carbon. However, the carious matrix of individual cavities varies from 47.05 per cent to 53.71 per cent carbon, the average being 48.17 per cent for duplicate analyses made on a large pooled sample. This is a relative loss of 4.6 per cent. The change in matrix by caries leads to formation of an insoluble black pigment on acid hydrolysis. The average yield is 3.78 per cent of the dry weight of carious matrix. No such pigment is obtained by acid hydrolysis of sound matrix, although a slight

amount of a soluble pigment is produced. The insoluble pigment has properties of melanins. Its average elemental composition, namely, C—69.51 per cent, H—8.31 per cent, N—4.27 per cent, O (by difference)—18.21 per cent, is similar (except for a higher carbon content) to values reported for melanins from skin, wool, melanotic tumors, etc. From these values the empirical formula is calculated to be $C_{18}H_{25}NO_4$.

7. RATE OF DENTIN FORMATION IN THE INCISOR TEETH OF GUINEA PIGS ON NORMAL AND ASCORBIC-ACID DEFICIENT DIETS. *Paul E. Boyle, D.M.D., and Otto A. Bessey, Ph.D., Dental and Medical Schools, Harvard University, Boston, Mass.* Intraperitoneal injections of alizarin were used to mark dentin formed during a 7 day period. Dentin measured along dentinal tubules on mid-enamel side near formative end of tooth averaged 95 microns. Width of dentin formed in same period increased from formative toward incisal part until maximum measurements of about 180 microns were reached. Farther incisally, near region where pulp chamber becomes obliterated, rate of dentin deposition was reduced and irregular. Beyond this point formation of tubular dentin ceased and calcified pulp tissue occupied tooth center. Animals kept on a basal ascorbic-acid free diet for 1 week deposited dentin which appeared normal except that the distance between alizarin lines was slightly less than in animals given supplements of greens or of ascorbic acid. During succeeding 3 days deposition of dentin with regularly arranged parallel tubules ceased abruptly in all parts. Dentin deposited between tenth and seventeenth days of deficiency was irregular, contained few tubules, and resembled dentin found in region where pulp chamber becomes obliterated in normal animals. Other groups of animals were given supplements of ascorbic acid in doses of 0.1, 0.25, 0.5, 0.75, 1.0, 2.0, and 5.0 mgm. per day after 7 day depletion period and dentin deposited between tenth and seventeenth days of experiment demarcated with injections of alizarin. Normal rates of dentin formation were found only in teeth of animals receiving 2.0 or more mg. per day. Near formative end of tooth, where distance alone dentinal tubules from the dento-enamel junction was less than 200 microns, width of dentin deposited was found to vary directly with dosage of ascorbic acid. Farther incisally, irregular dentin with few tubules was found. Lower the

dosage the nearer formative end this type dentin occurred. An assay method based on these findings is being perfected.

8. DICALCIUM PHOSPHATE AND CODLIVER OIL AS FACTORS IN PREVENTING INFERIOR CALCIFICATION OF THE DENTIN DURING ARTIFICIALLY INDUCED FEVERS. *Paul C. Kitchin, M.S., D.D.S., and Milton Berman, M.S., College of Dentistry, Ohio State University, Columbus, Ohio.* In studying effects of artificially induced hyperpyrexia upon incisor teeth of young rabbits, dentin was discovered to be marked by linear areas of interglobular spaces, corresponding to periods of fever. There was no effect on teeth of old rabbits. When young albino rats were similarly treated, the same results occurred in dentin. The enamel in all cases appeared unaffected. Since artificial fever is an accepted therapeutic method in pediatric practice, it seemed desirable to find some way of avoiding this undesirable effect in dentin of developing teeth. Because fever accelerates all metabolic activities, it appeared logical to try fortification of diet in those constituents concerned with calcification. Fifteen litters of albino rats were each divided into 2 groups, one receiving only a basal diet, and the other the basal diet supplemented with dicalcium phosphate and codliver oil. Half of each group was subjected to induced high temperatures, and the other half served as controls. Temperatures reached 109.6°F., for fortified animals, and 108°F., for unfortified animals. None of the animals receiving dicalcium phosphate and codliver oil exhibited dentinal dystrophy after fevering. Nearly all the fevered animals on the basal diet, and all which survived temperatures over 108°F., showed dentinal hypocalcia correlated with the fever period.

9. BACTERIA IN DENTINAL TUBULES OF GANGRENOUS TEETH. *W. A. Figg, D.D.S., Northwestern University Dental School, Chicago, Ill.* In reviewing the literature many references to bacteria in root canals, accessory canals and dentinal tubules of gangrenous teeth have been found. Histological pictures of root canals and accessory canals support these descriptions but the author has been unable to find similar illustrations in dentinal tubules. The only dentinal tubules that were shown with bacteria were in carious areas. It has been found that in gangrenous teeth there is an invasion of the tubules by bacteria that is dissimilar to that of caries. In caries it seems that

the bacteria attack the Tomes' fibers and are seen in the center of the tubules, which widen due to the decalcification and dissolution of the organic matrix. In gangrenous invasion this decalcification and dissolution is not found and the bacteria are on the walls of the tubule. Although the penetrations, observed to date, vary up to 0.75 mm., bacteria have not been observed to penetrate to the dentino-cemental junction or in the cementum corpuscles around the apices.

10. DECALCIFICATION ARRESTED IN VITRO. *J. T. Gore, D.D.S., Philadelphia, Pa.* Incipient decalcification (white or opaque areas with surface intact) of enamel produced *in vivo* was arrested *in vitro* by thorough dessication with warm 95 per cent alcohol containing 1 per cent of thymol, followed by warm approximately absolute alcohol and then acetone, all applied to teeth from spray bottles. A nitrocellulose-acetone-amyl acetate solution was finally sprayed on the teeth, the solution thoroughly dried with warm air, the surface coating removed and the teeth placed in 10 per cent lactic acid for 16 hours. The sound enamel was dissolved away leaving the original decalcified area which was impregnated with hardened nitrocellulose, standing in relief, unaffected by the acid. The rubber dam was adjusted to one quadrant of the mouth at a time and the above technique used on a few selected patients. When hypersensitive areas had previously existed, due to exposure of the cementum or dentin, they were partially or wholly relieved. No deleterious effect upon the pulp has been noted thus far. The hardened nitrocellulose is insoluble in acids and fresh or stagnant saliva. This is a preliminary report; the investigation is still in progress and an effort is being made to arrange extensive experiments, *in vivo*, under test conditions.

VI. SECOND SESSION: AFTERNOON, MARCH 13; ABSTRACTS 11–22

11. STREPTOCOCCI ISOLATED FROM THE MOUTH. *Hazel I. Tefft, A.B., and B. G. Bibby, B.S.D., Ph.D., School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.* Fifty-two strains of streptococci isolated from human mouths were tested and classified according to the method of Sherman. On the basis of growth at 45°C. and 10°C., they fell into 3 groups. Twenty-six strains were classified as *Streptococcus salivarius*, 16 as *Strep. lactis* and 10 as *Strep. fecalis*. Bio-

chemical tests were carried out on all strains. The *Strep. fecalis* group was more actively saccharolytic than the other groups. The relationship of these organisms to dental caries is being investigated.

12. ACID PRODUCTION BY MOUTH ORGANISMS. *Mary Van Kesteren, A.B., and B. G. Bibby, B.S.D., Ph.D., School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.* To measure the amount and rate of acid formation, titrations with 0.1 NaOH and colorimetric pH determinations were carried out at time intervals in 10 cc. amounts of glucose Douglas broth cultures of various mouth organisms. Streptococci formed acid most rapidly producing an average of 2.31 cc. of 0.1 N acid and a pH as low as 4.5 in 8 hours. Lactobacilli were less rapid in their action giving an average of only 0.83 cc. acid in the same period of time. In 48 hours, however, they formed an average of 3.23 cc. acid (pH 4.2). Actinomyces ranked second to streptococci in rapidity of acid formation, but like them reached their peak in 24 hours. Gram-negative cocci, Gram-positive micrococci, fusiformis, leptotrichia and a Gram-negative bacillus ranked in that order as acid producers, the last producing absolutely no acid. The streptococci fell into 2 groups relative to acid formation, one forming about 25 per cent more acid than the other. Since the rapidity of acid formation is an important factor in dental caries, it seems likely that the streptococci are an important bacterial cause.

13. THE EFFECT OF ENAMEL AND DENTIN ON THE FORMATION OF ACID BY MOUTH BACTERIA. *B. G. Bibby, B.S.D., Ph.D., School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.* The effects of enamel and dentin on formation of acids by mouth bacteria were tested by comparing titratable acidity, pH, bacterial population and weights of tooth substance lost in series of glucose Douglas-broth cultures of mouth bacteria. Cultures of lactobacilli and some streptococci formed more acid on addition of tooth substance, dentin having more effect than enamel. Other streptococci formed less acid in the presence of enamel and dentin. In a few tests, acid production by leptotrichia was reduced by both enamel and dentin, reduction by the latter being greater. Stimulation of acid production by rat dentin was more marked than by human dentin. Although much lower levels were reached in control flasks, the pH never fell below 5 in presence of dental tissues, indicating that in a

biological system pH 5 is critical level for decalcification of both enamel and dentin. Growth rate was the same in control and test cultures, but population of more aciduric streptococci was maintained for a longer time in presence of tooth substance. Loss of enamel and dentin was proportionate to acid production regardless of type of organism or length of incubation periods. The findings that streptococci dissolved more tooth substance than other organisms in short periods of time and that activities of some types appeared to be stimulated by presence of enamel and dentin suggest that these organisms are of primary importance in causation of dental caries.

14. EFFECT OF LOCAL AND SYSTEMIC FLUORINE-ADMINISTRATION ON EXPERIMENTAL RAT-CARIES. *Reidar F. Sognnaes, T.L. (Oslo), School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.* The effect of 2 separate methods of fluorine administration has been studied in rats (with completed dentition) fed a caries-producing diet for 100 days. 1. At weekly and monthly intervals aqueous fluoride-solution (F) was applied locally to the mandibular right molars by means of an apparatus designed for insertion in the mouths of anesthetized rats. 2. Other groups were given fluorine (F) through stomach tube each second day. Results: 1. Fluorine brought in contact with the tooth surfaces may increase the resistance to incipent lesions. 2. Fluorine brought into the system reduces the number of cavities, severe tooth-destructions, and pulp-involvements, even when the salivary glands are removed. This suggests that the destruction of fully formed dentin is inhibited by a systemic action of fluorine.

15. EFFECT OF VITAMIN D ON THE ERUPTION OF DECIDUOUS INCISORS. *Thomas D. Speidel, D.D.S., M.S., College of Dentistry, State University of Iowa, Iowa City, Ia.* In a carefully controlled in-patient study, the times of eruption of the deciduous lower first incisors of groups of healthy infants were compared. Diets differed only in the amount of supplementary vitamin D given. Incisors of 22 infants given 300 to 400 units of vitamin D daily showed the earliest mean age of eruption, 24.97 weeks. Incisors of 17 infants with 135 to 270 units daily were delayed in their eruption, appearing at a mean age of 29.06 weeks, a statistically significant difference from the 300–400 unit group. Incisors of 6 infants receiving over 1800 units daily also seemed delayed in their eruption, appearing at a mean age of 28.0

weeks. The dental eruption data of 6 infants who had 300 to 400 unit intake but were subject to severe acute or mild chronic illnesses were presented. Mean age of incisor eruption of this group, 29.54 weeks, seemed to indicate that illness delays tooth eruption and that earlier eruption is more nearly normal. The response of dental eruption to variations in vitamin D intake tends to parallel the responses of linear growth and mineral retention to the same influence during infancy.

16. CHEMICAL ANALYSES OF DECIDUOUS TEETH. *M. J. Bird, A.B., Ethel L. French, Ph.D., M. Woodside, A.B., M. Morrison, Harold C. Hodge, Ph.D., College of Arts and Science and School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.* Forty-five deciduous teeth from children aged 5 to 12 were obtained from the Rochester Dental Dispensary. Only 2 teeth were non-carious. The teeth were separated into dentin and enamel; both were analyzed for percentages of moisture, organic matter, calcium and phosphorus. Deciduous tooth composition was found to be similar to that of adult tissues. Calcium/phosphorus per cent ratios lay between those for fetal and adult teeth. This indicates that the tissues contain the same principal fundamental inorganic molecule, but that some sort of chemical maturation is involved. The composition (per cent) of deciduous enamel and dentin as found by these analyses is as follows:

Moisture		Organic		Ca		P		Ca/P	
E	D	E	D	E	D	E	D	E	D
2.8	11.1	4.9	24.0	36.0	33.3	17.8	16.5	2.06	2.08

Moisture is calculated as per cent moist weight; organic matter, per cent dry weight; calcium and phosphorus, per cent inorganic weight. No significant difference in composition was found when tissues were classified according to caries class, tooth location, age and sex of subject.

17. THE HISTOPATHOLOGY OF RAT CARIES. *S. S. Arnim, D.D.S., Ph.D., School of Dentistry, Medical College of Virginia, Richmond, Va.* Carious lesions were demonstrated in some of the maxillary and mandibular molar teeth of 147 rats. Maxillary right first and second molars were extracted from 54 animals at weaning. Rations were composed of purified foodstuffs with definite physical characteristics.

Little evidence was obtained concerning the etiology of caries. The mode of progress of "cusp or fracture" lesions was observed revealing a definite correlation between lack of dentin formation and occurrence of this type lesion. Specimens were obtained revealing morphological characteristics of food particles retained on tooth surfaces, plaques and mode of progress of lesions in enamel and dentin. Caries was observed in rats fed adequate, low-salt, sifted or unsifted diets. It occurred on cusps of teeth with no antagonists, on cusps of teeth with antagonists, at the bottom of pits, on the sides of fissures and on proximal surfaces. A marked increase in caries incidence was observed in all mandibular molars and maxillary right third molars of rats with teeth extracted. Jaws were decalcified by a method that maintained relationships of plaque, enamel remains, and other tissues. The material was sectioned serially at 7 micra.

18. A SECOND CENSUS OF DENTAL CARIES AMONG ENTERING FRESHMEN AT THE UNIVERSITY OF MINNESOTA. *Peter J. Brekhus, B.A., D.D.S., School of Dentistry, University of Minnesota, Minneapolis, Minn.* This report presents a follow-up study on one made in 1929. The number of students examined was 3,888 in 1929, 4,348 in 1939. The most striking comparative findings were, in the 1939 group, a 4 per cent increase in total number of teeth affected by caries, or an increase of 1 tooth per student; a rather marked increase in caries of the second molars; and a decrease in the number of perfect mouths found. Since these differences are all statistically significant, they may indicate an increasing susceptibility to caries in young people of college entrance age. In both the 1929 and 1939 groups, the men had slightly better teeth than the women. The pattern of comparative susceptibility of individual teeth was virtually the same as in 1929. A considerable increase in amalgam fillings and a corresponding decrease in gold fillings was noted in the 1939 group.

19. FOLLOW-UP STUDIES OF ROOT FILLED TEETH TWO YEARS AFTER THE COMPLETION OF TREATMENT WITH SOME BACTERIOLOGICAL FINDINGS. *M. F. Yates, D.M.D., and F. W. Morse, Jr., M.D., Dental and Medical Schools, Harvard University, Boston, Mass.* Types of organisms obtained in cultures made from root canals during the strictly aseptic technique of treatment have been reported by us and by others. Cases which we have handled in this manner have now

been observed for some years. Interesting correlations are suggested, between the types of initial condition as radiographically observed and the character of the bacteriological findings. Two hundred and sixty-five cases form a series which have been followed from 1 to 8 years after the root canal filling was placed. Of the 265 cases studied 19 (7 per cent) show no improvement radiographically. Thirty-two normal cases originally observed all continued normal. One hundred and thirty-eight cases (52 per cent) show a definite positive improvement; and 76 cases (29 per cent) show a very marked improvement, in many cases with complete return to normal of the periapical tissues. The follow-up checks of this series of cases include both clinical and radiographic observations. From our studies, root canal therapy carried out under strict asepsis with bacteriological controls and adequate follow-up observation is a procedure in keeping with modern ideals.

20. A METHOD OF MEASURING THE DISPLACEMENT OF TISSUES UNDER DENTURES. *Carl O. Boucher, D.D.S., College of Dentistry, Ohio State University, Columbus, Ohio.* An instrument for measuring the tilt of denture bases under central and lateral bearing points was described, together with 2 technics for its use. It can be used on specially prepared bases or upon completed practical dentures for studying the displacement of tissues under denture bases.

21. EFFECTS OF ELECTRO-STERILIZATION OF PATHOGENIC MICRO-ORGANISMS. *H. Zelson, B.S., D.D.S., School of Dentistry, Washington University, St. Louis, Mo.* Three series of experiments were carried out to evaluate the effect of electrosterilization on pathogenic micro-organisms taken from infected root canals. 1. Electrodes were placed 2 inches apart in pour plates and attempts made to determine value of impressing the effect of one electrode on that of opposite charge. Positive electrode was found effective, negative ineffective; impressing effect of negative on positive or vice versa gave no advantage; bacterial effect was directly proportional to time of application of positive electrode. 2. Varying the distances between electrodes on 12 inch pour plates had no effect on the area of bactericidal effect at the poles and showed no interpolar effects. 3. ZnI_2I_2 solution was added to series of tubes with bacterial broth cultures. After allowing a period for anti-bacterial action equal portions were added to molten agar in

test tubes and in U-tubes. Negative electrode was applied in one arm of U-tubes, positive in other; test tubes were left without further treatment. The positive electrode effected destruction of bacteria with a concentration of drug ineffective alone; negative electrode was no more effective than the drug alone.

22. GALVANIC ACTION IN THE ORAL CAVITY. *N. F. Robbins, D.D.S., School of Dentistry, University of Pennsylvania, Philadelphia, Pa.* The most important of several factors in the production of galvanic action is the presence of 2 or more dissimilar metals in an electrolyte. Such a condition is frequently found in the oral cavity. After consultation it was decided to use an apparatus and method to obtain micro-voltage rather than micro-amperage readings. Clinical patients were observed and varying objective and subjective symptoms recorded. In some instances pronounced reactions were noted with relatively low electro-potentials. Only removal of one of the dissimilar metals brought relief in certain individuals. In the range of normal intra-oral pH values significant changes in micro-voltage was not demonstrable. The pathway of current varies in each individual and depends largely on resistance offered to its passage. Current probably does not flow continuously but may pass momentarily when conditions are favorable.

VII. THIRD SESSION: EVENING, MARCH 13; ABSTRACTS 23–33

23. A STUDY OF THE GENERAL PREDISPOSING FACTORS OF PARODONTAL DISEASE. *Herbert T. Kelly, M.D., Herman R. Churchill, D.D.S., D.M.D., and John H. Gunter, D.D.S., M.D., University of Pennsylvania, Philadelphia, Pa.* A medical study of patients with and without various parodontal conditions, usually grouped as parodontoses, was approached by making 2871 physical and clinical laboratory tests on 2 groups of patients. Of 130 individuals, 6 to 75 years of age, examined all suffered from some form of ill health, 111 also had parodontosis and 19 were free from parodontal disease. The incidence of abnormal laboratory findings in the parodontosis group was 65.6 per cent, in the control group 61.3 per cent, a difference not considered significant. Seven clinical laboratory tests which might indicate absorption, storage and utilization of foodstuffs and essential food factors in the diet were selected. Four of these findings seemed

significant: Biliary tract disease was present in 69.2 per cent of 13 controls; in 86.5 per cent of 89 parodontosis patients. The B.M.R. was abnormal in 22 per cent of 9 controls; in 50 per cent of 78 parodontosis patients. The 1 hour 2 dose glucose tolerance test extended over 6 hours was abnormal in 66.7 per cent of 9 controls; in 79.4 of 77 parodontosis patients. The galactose test was abnormal in 50 per cent of 8 control cases; in 60.9 per cent of 64 parodontosis patients. Our results thus far seem to indicate: the absorption of foodstuffs and essential food factors from the small intestine is considerably more impaired in individuals who suffer from parodontal disease than in those who do not. The processes of cellular oxidation, storage and utilization are similarly markedly diminished in those with parodontal disease.

24. A STUDY OF THE PHOSPHORUS METABOLISM IN THE DENTAL TISSUES OF A CAT BY THE USE OF RADIOACTIVE PHOSPHORUS. *J. F. Volker, D.D.S., M.S., and R. F. Sognnaes, T. L. (Oslo), School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.* Seventy-two milligrams of Na_2HPO_4 containing an appreciable amount of radioactive phosphorus (P^{32}) was given by stomach tube to a young adult female cat. Nine days later the animal was sacrificed and the radioactive isotope content of the jaws and teeth measured by means of a Geiger-Müller counter. The maxillary and mandibular bones contained approximately 4 times as much marked phosphorus per gram of inorganic tissue as the dentin, with greater amounts being found in the maxilla. Forty-four thousandths per cent of the total dose was found in the whole dentition. Of this approximately 91 per cent could be accounted for in the dentin and 2.3 per cent in the enamel. Almost all the radioactive phosphorus in the dentin was in the inorganic phase. Surface enamel removed by grinding with the aid of a binocular microscope showed greater concentrations of P^{32} than the inner layer of enamel which was separated from the dentin by the method of Manly and Hodge. This suggests that the surface enamel may be capable of adsorbing phosphorus from the saliva.

25. DENDRITIC CELLS IN THE ALVEOLAR GINGIVA AND ENAMEL ORGAN; PHAGOCYTIC CELLS IN THE ENAMEL ORGAN. *Milton Berman,*

M.S., College of Dentistry, Ohio State University, Columbus, Ohio. From fresh postmortem material of a white male child of 11 months, sections of unerupted deciduous incisors and of permanent tooth buds were prepared and stained with hematoxylin and eosin, and with Bodian's activated protargol stain. H and E sections revealed nothing unusual. Bodian's stain revealed in both the alveolar gingiva and in the enamel epithelium of the permanent and deciduous tooth buds, large dark-staining dendritic cells with beaded processes, resembling unipolar and multipolar neurones. The cells gave a dopa positive reaction and were interpreted as melanoblasts. They resemble similar cells in the skin. Occurrence in the enamel organ was less numerous than in the gingivae. The literature, available to the writer, makes no mention of this type cell in the enamel organ. Similar dendritic cells were found in normal alveolar gingiva, but fewer in number and varying in distribution from those cells observed in the tissue obtained in the above case. In the enamel epithelium of the deciduous incisor tooth were large phagocytic cells in the act of engulfing epithelial cells and creating hyalinated areas. The available literature makes no mention of this phenomenon. These observations indicate the possibilities of study of the dental tissues with special stains. (To be published in *J. D. Res.*).

26. STAINING OF THE DENTAL STRUCTURE IN JAUNDICE OF THE NEW BORN. *Paul K. Losch, D.D.S., John C. Brown, D.M.D., and Paul E. Boyle, D.M.D., Harvard University Dental School, Boston and Childrens' Hospital, Boston, Mass.* Unstained ground sections were prepared of a tooth recovered from a 9½ year old child, diagnosed at birth as a case of icterus gravis neonatorum. The neonatal lines in the enamel and dentin were colored bright green. A tendency of the structures to fracture at these lines was noted.

27. EOSINOPHILE LEUKOCYTES IN PULP AND GINGIVA. *Balint Orban, M.D., D.D.S., Northwestern University Dental School, Chicago, Ill.* A large number of eosinophile leukocytes can be found in inflammation of the dental pulp as well as in that of the gingiva. These leukocytes are mostly found in chronic inflammation, but are seen also in acute conditions. The eosinophile leukocytes migrate from the blood vessels into the tissues due to some kind of chemotactic influ-

ence, most probably tissue decomposition. It is also claimed that their presence in the inflamed tissue is an indication of higher pressure in the tissues.

28. THE INCIDENCE OF IMPACTED LOWER THIRD MOLAR. *Ronald Barber, D.D.S., Bernard H. Faubion, B.S., D.D.S., and Lewis H. Daniel, D.D.S., Dental Corps, United States Navy, Annapolis, Md.* On the premise that impacted lower third molars are a menace a decision was made to remove such impacted third molars from the mouths of a large number of students as soon, after making the diagnosis, as possible. The incidence was higher than anticipated so that insufficient time had been allowed for the total number of cases. There was need for an accurate record of incidence of impacted lower third molars for use in such planning. This would be of value to anyone undertaking a similar service. Accordingly the next class, composed of 792 male white American students, between the ages of 16 and 20 years, was examined in a uniform manner. Any lower third molar area in which a third molar was not erupted was subjected to radiographic examination whether or not the student gave a report of earlier extraction of a tooth from that region. Details together with some break-down of the statistics derived are given.

29. POSTERUPTIVE TOOTH AGE AND DIFFERENCES IN THE CARIES SUSCEPTIBILITIES OF THE SEVERAL PERMANENT TEETH. *Henry Klein, D.D.S., Sc.D., and Carroll E. Palmer, M.D., Ph.D., Division of Public Health Methods, National Institute of Health, Bethesda, Md.* A description of the analysis used in, and the findings which have resulted from, an attempt to express the different caries tendencies of the several permanent teeth in terms of the length of time the teeth are exposed in the mouth after eruption—posteruptive tooth age, are given. When the caries susceptibilities of the several permanent teeth are derived on the basis of this factor, it is found that the caries susceptibilities of the permanent teeth of boys do not differ significantly from those of girls. Furthermore the derivation of caries rates on the basis of length of exposure of teeth in the mouth makes it evident that the teeth making up the permanent dentition (data on third molars are not included in the study) do not become attacked by caries in individually different ways. The findings reveal that, irrespective of extreme differences in morphological form and time of

eruption, certain of the permanent teeth have caries susceptibilities of markedly similar character—the 14 corresponding pairs of permanent teeth tending to fall into 5 susceptibility classes. These, in order from highest to lowest susceptibilities, are as follows: Class I—mandibular first and second molars; Class II—maxillary first and second molars; Class III—maxillary first and second incisors, maxillary first and second premolars and mandibular second premolars; Class IV—mandibular first premolars and maxillary canines; Class V—mandibular first and second incisors and mandibular canines.

30. AN EVALUATION OF ROOT RESORPTION OCCURRING DURING ORTHODONTIC TREATMENT. *C. E. Rudolph, D.D.S., University of Minnesota, School of Dentistry, Minneapolis, Minn.* Efforts were directed at evaluating the validity of the belief that, other things being equal, root resorption occurs more frequently during orthodontic treatment and at prognosticating root resorption. Serial radiographs of 439 orthodontic patients (ages 7–21) used in an earlier study were compared with those from 4,560 patients (ages 7–79) with no history of orthodontic treatment. The incidence of root resorption in the latter group was 13 per cent. In 739 patients between 7 and 21 years of age only 5 per cent, all over 13 years of age, showed resorption compared with 49 per cent at the end of 1 year of treatment and an additional 75 per cent at the end of 2 years in the orthodontic patient group. In a group of 513 orthodontic patients treated by undergraduates (labial arch appliances with fixed attachments and bands with ligatures), the incidence of root resorption was compared with age, sex and duration of treatment. Data obtained indicates that orthodontic treatment is less hazardous to root structure when initiated at an early age and that prolonged treatment in younger patients is less liable to produce loss of root tip structure. (To be published in *J. D. Res.*)

31. THE INFLUENCE OF THE FORMATIVE DENTAL ORGANS ON THE GROWTH OF THE FACIAL BONES. *Lawrence W. Baker, D.M.D., Dental School, Harvard University, Boston, Mass.* The experiments here reported were to determine the part formation and eruption of teeth play in growth of the bones of the face. The first experiment was to remove by means of a tiny aspirating needle from a series of 3 weeks old rats, the formative organ of 1 upper incisor, the tooth itself being

allowed to remain. The corresponding incisor on the other side was, of course, allowed to grow normally. The results revealed that after these animals were fully grown the induced unilateral condition brought about an extraordinary bony asymmetry. In each instance, the bones were markedly twisted by the power of the normally growing tooth towards the side from which the formative organ of the tooth on the other side was removed and in the direction of the line of growth of the tooth. These experiments were also applied to animals whose dentitions resembled man in that they possess both deciduous and permanent teeth. Kittens were selected at age of weaning, all formative organs of permanent teeth present at that time being removed by aspiration from the right maxillary bone. The experiment extended over a period of 2 months and 9 days. (It terminated then only because the deciduous teeth showed signs of loosening). It was noted among other changes which occurred during this short time that arrest in bone growth on the side from which formative organs were removed, was so great as to appreciably affect the position of the floor of the orbit, in being on a lower plane from its fellow on the unoperated side.

32. CONGENITAL ABSENCE OF TEETH. *Ralph W. Edwards, D.D.S., Kansas City-Western Dental College, Kansas City, Missouri.* Oligodontia occurred in 5 of a family of 8 children. The male parent has right maxillary and mandibular third molars absent; the female parent is edentulous, with history of being "snaggle-toothed" and with several teeth missing, losing remainder of teeth at age 32. Child 1, female, has 11 teeth missing; child 2, female, has normal dentition, right maxillary third molar missing; child 3, male, has 16 teeth missing; child 4, female, has 29 teeth missing; child 5, female, has 14 teeth missing; child 6, male, has normal dentition, maxillary third molars missing; child 7, male, has 14 teeth missing; child 8, male, has normal dentition, all third molars missing. In the 5 affected children a total of 84 teeth are missing (52.5 per cent). Children 2, 6 and 8 (the unaffected group) all have some third molar deficiency. In this family the characteristic of tooth deficiency apparently follows a hereditary pattern that is not sex-linked. The hereditary predisposition comes from both mother and father, one having multiple tooth deficiency, the other third molar deficiency.

33. THE HISTOPATHOLOGY OF THE TEMPOROMANDIBULAR JOINT IN DISEQUILIBRATION OF MASTICATORY STRAINS. *W. H. Bauer, M.D., School of Dentistry, St. Louis University, St. Louis, Mo.* Previous histological studies of the temporomandibular joints obtained from 17 bodies have been supplemented by recent investigations. Changes of structure of condyle, fossa, articular eminence as well as of the meniscus which were more or less pronounced and visible were revealed. Radiographic studies of mandibular articulations did not show marked alterations in all cases. Unequally distributed or violent strains, i.e., disequilibrium of masticatory stresses due to loss of teeth supporting the normal relationship between condyle and fossa, affects the elastic cartilage which covers definite parts of the joint bodies. The cartilage layer which normally protects subchondral bone against functional and mechanical damage is injured. The constant irritation, even from normal function, of such a damaged temporo-mandibular articulation will produce progressive alterations of the articulatory surfaces and the meniscus. Gradually symptoms of a chronic non-infectious proliferative inflammation, osteo-arthritis deformans, develop. The early miscroscopic picture of arthritis deformans is characterized by splitting of the ground substance of cartilage followed by vascularization and ossification starting in the subchondral marrow spaces and invading the cartilage. Hemorrhages and microscopic cysts may be found in traumatogenically exposed subchondral marrow spaces. Characteristic exostoses, independent of the periosteum, are developed as a result of changes in the subchondral marrow. The meniscus shows all stages of degeneration from calcification up through and including complete destruction.

VIII. FOURTH SESSION: MORNING, MARCH 14; ABSTRACTS 34–46

34. COMPARATIVE MEASUREMENTS OF SALIVARY pH BY THE QUINHYDRONE AND GLASS ELECTRODES. *George D. Wessinger, Ph.D., Foundation for Dental Research of the Chicago College of Dental Surgery, Chicago, Ill.* Previous investigations by the author have demonstrated that there are compounds in saliva which can serve as hydrogen donors for the reduction of pyruvic to lactic acid. Since the measurement of salivary pH by the quinhydrone method is an oxidation-reduction reaction it seemed desirable to investigate the results ob-

tained by this method as compared to the glass electrode. The differences obtained by the 2 methods varied somewhat but the average difference for 50 measurements was 0.08 pH units. The quinhydrone method usually gives a lower value. Attempts were made to measure the oxidation-reduction potential of saliva to determine if a correlation existed between this and the deviation in pH by the 2 methods. Redox potentials of saliva have not as yet been successfully measured because of polarization effects. Further work is in progress.

35. QUANTITATIVE RELATIONSHIP BETWEEN SALIVA AND CARIES IN AN ADOLESCENT GROUP. *F. H. Cushman, D.M.D., J. W. Etherington, D.M.D., and G. E. Thompson, D.M.D., Harvard University, Dental School, Boston, Mass.* As a continuation of the work started by Trimble, Etherington and Losch, 21 adolescent patients (13–16 yrs.) were examined clinically with aid of radiographs at 1 year intervals by the same clinician. Paraffin stimulated salivary secretions for 10 minute periods were collected under similar conditions on repeated tests. Average secretion for the whole group 16.9 cc. Amounts ranged from 7–34 cc.: a. No new caries group—secretion range 16–34 cc. Ave. 22.1 cc. b. 1–3 new smooth surface cavities —secretion range 10–23 cc. Ave. 16.3 cc. c. 4 or more new smooth surface cavities—secretion range 7–16 cc. Ave. 12.3 cc. A total of 55 samples from 24 individuals yields a total of 38 possible individual variations. Of this number, 24 did not vary more than $\pm$ 2.5 cc.; 32 not more than $\pm$ 5 cc. No diagnostic significance can be attached to this relationship when considering individuals. The trend indicates, however, that some relationship does exist between caries susceptibility and salivary secretion and, to a large degree, amounts of secretion are reproducible under similar conditions.

36. EXPERIMENTAL AND CLINICAL STUDIES ON THE ERUPTION OF TEETH. *I. Schour, D.D.S., Ph.D., College of Dentistry, University of Illinois, Chicago, Ill.* Theories on the eruption of teeth were subjected to specific experimental analysis to test their validity. The continuously erupting rodent incisor is a valuable tool for such studies. In addition, clinical observations on normal and abnormal eruption of human teeth were evaluated and were found to simulate the experimental procedures and confirm the findings. While evidence on the

mechanism of eruption is at present inconclusive, and in the main tends only to negate present theories, certain conclusions may be drawn: 1. Eruption is independent of growth of the tooth itself. It is not dependent upon elongation of root, growth of dentin or pulpal constriction, proliferation of Hertwig's epithelial sheath, growth of alveolar bones or pull by periodontal fibers. 2. Eruption appears to be the resultant of a force acting upon the root of the tooth to extrude it into the oral cavity. Eruption is inhibited or deflected by mechanical obstructions (antagonist, deciduous predecessor, dense overlying bone, impactions) whose removal permits full expression of the eruptive potential. 3. A significant correlation is suggested between vascularity of the peri-radicular tissue and rate of eruption in both systemic (hypophysectomy, hypo- and hyperthyroidism) and local effects (vasomotor disturbances). Experimental modifications of the vascularity of the periodontal tissues may clarify further the mechanism of eruption.

37. PHYSICAL PROPERTIES OF ZINC PHOSPHATE CEMENTS BASED ON A POWDER-LIQUID RATIO CALCULATED FROM THE INVOLVED CHEMICAL REACTION. *J. V. Mitchell, B.S., D.D.S., College of Dentistry, University of California, San Francisco, Cal.* Previous comparisons have been made of the various commercial cements. These comparisons are based on a powder-liquid ratio obtained empirically with a rigid mixing technic. Since the reaction velocities of the various cements are different, the work in this report is based on a powder-liquid ratio calculated from the chemical equation of the reaction taking place when cements are mixed. With this ratio established, variations in mixing technic can be made. This will then not discriminate against fast setting cements and a comparison of all cements can be made based on a powder-liquid ratio similar in all cases. This paper discusses the method involved in determining the powder-liquid ratio and the reasons for this approach.

38. ABRASION OF DENTAL GOLD ALLOYS. *E. W. Skinner, Ph.D., and R. L. Lasater, D.D.S., Northwestern University Dental School, Chicago, Ill.* The amount of abrasion which occurs under identical conditions of test has been determined quantitatively for 6 dental gold alloys, both in the "softened" and "hardened" condition, and for tooth enamel. It is conservatively estimated that the tooth enamel is at

least twice as resistant to abrasion as the most abrasive resistant alloy. The age-hardened alloys exhibited more abrasion than when the same alloys were in the "softened" condition. There is a possible relation between the Brinell hardness number and the amount of abrasion, but the proportionality is not valid in all cases. A direct proportionality was found to exist between the specific gravity and the amount of abrasion of the alloys in the "softened" condition.

39. A STUDY OF THE ANNEALING TEMPERATURE OF GOLD FOIL. *H. W. Peterson, D.D.S., M.S.D., Loyola University, School of Dentistry, New Orleans, La., and E. W. Skinner, Ph.D., Northwestern University Dental School, Chicago, Ill.* Authorities are divided as to whether the annealing of gold foil has any other effect than to drive off surface adsorbed gases or as to whether there is relief of strain hardening as in the annealing of plate metal. The specimens used in this investigation were annealed for 3 minutes at temperatures ranging from 200°C to 950°C, at 50° intervals. The data recorded shows that there is a direct relation between the annealing temperatures, and Brinell hardness, specific gravity, and voids. It is evident that the lower annealing temperatures are to be preferred for this particular type of gold foil.

40. BACTERIA IN DENTIN AFTER CAVITY PREPARATION. *H. A. Zander, D.D.S., Northwestern University Dental School, Chicago, Ill.* In 4 out of 10 cavities cut in carious teeth having no pulp involvement, bacteria remained in the dentin of cavity walls or floors after all softened material had been removed. The bacteria were found 0.08 mm to 1.2 mm within the hard dentin and their distance from the pulp varies from 0.24 to 1.9 mm.

41. THE ADVANTAGES OF GROUND SECTIONS IN THE HISTOLOGICAL STUDY OF TEETH. *Chas. F. Bodecker, D.D.S., School of Dental and Oral Surgery, Columbia University, New York, New York.* The most commonly used method of examination is decalcification but the grinding method offers advantages not commonly known. Besides preserving the enamel and clearly demonstrating differences of calcification in dentin, it throws light on changes resulting from caries and abrasion. The grinding technique is the only method to show the changes which occur in teeth some years after eruption. This change has been termed "protective metamorphosis," first noted

by Beust. The presence of the dental lymph and the difference in the appearance of the dentin when this fluid is absent can be determined only by the grinding technique of preparing specimens. A knowledge of the microscopic structure of the calcified tissues of the teeth, based on a single method of preparation is incomplete. Both decalcification and the grinding of specimens are necessary to advance our knowledge of dental histology.

42. TEMPOROMANDIBULAR BONE CHANGES RESULTING FROM RAISING THE BITE. *Carl Breitner, M.D., Columbia University, School of Dental and Oral Surgery, New York, N. Y.* In a series of experiments on monkeys it has been shown that specific bone changes in the temporomandibular joint and in the angle of the mandible can be traced to specific methods of orthodontic treatment applied to these monkeys. The use of bite planes which raised the bite in the anterior region proved to have an effect on these parts of the skull similar to that of intermaxillary rubber bands in Class II direction. To study the reasons for this resemblance (which corroborates clinical experience) a model was constructed which shows the mechanical reasons for the beneficial effect of bite planes in Class II malocclusions. This effect consists of a forward movement of the body of the mandible, including the chin, thus improving the facial contours in the majority of Class II cases. In accordance with the histological findings and their mechanical explanation, a new method of treatment for Class II malocclusion is suggested which consists of 2 consecutively used bite planes, the first raising the bite in the anterior region and the second subsequently raising the bite in the molar area.

43. RED MARROW IN THE JAWS. *Lester R. Cahn, D.D.S., Columbia University, School of Dental and Oral Surgery, New York, N. Y.* Aside from 2 papers by Box there has been no work published in English on this subject. The prevailing type of marrow found in the jaws is yellow marrow. Red or hematopoietic marrow, however, does exist in a number of instances. It is usually found in isolated areas. It may be the remains of fetal deposits or those persisting from early childhood. On the other hand red marrow may be the result of adaptive activity following local or generalized infections, hemorrhage, blood dyscrasias, anoxemia, or any condition that will call for an increase in blood cells. Foci of red marrow are accompanied by

rarefaction of bone. This fact is signalized in the radiograph by radiolucent areas which may be mistakenly interpreted as zones of infection and needlessly operated upon.

44. FORMATION OF THE HUMAN ORGANIC ENAMEL MATRIX AND ITS CALCIFICATION. *M. Diamond, D.D.S., and J. P. Weinmann, M.D., Columbia University, School of Dental and Oral Surgery, New York, N. Y.* Evidence is presented that the existing concept of linking enamel formation with its calcification is not substantiated. The full adult width of the enamel matrix is first formed. The calcification or the so-called final maturation stage then begins at the highest point of the crown radiating in a direction towards the dentino-enamel junction, and laterally until the incisal or the occlusal surface areas are calcified. Calcification then continues in a cervical direction until the peripheral surfaces are complete. The direction of such calcification is therefore directly opposite to the incremental lines and more nearly parallel to the bands of Shreger. Additional evidence is presented that the entire enamel epithelium becomes reduced or undifferentiated to form the united enamel epithelium, not after the final maturation stage as is generally believed, but at the stage of completion of the full adult thickness of enamel matrix.

45. HISTOGENESIS OF ENAMEL HYPOPLASIA. *M. Diamond, D.D.S., and J. P. Weinmann, M.D., Columbia University, School of Dental and Oral Surgery, New York, N. Y.* Evidence is presented, with human embryologic material, that the initial lesion in the formation of enamel hypoplasias is definitely in the ameloblasts. A series of stages are noted, from a mild incipient lesion showing enamel secretion in globular form, to extensive areas of cystic degeneration of ameloblasts. Additional evidence shows a deposition of the expelled enamel secretion from the involved ameloblasts to form hypoplastic areas upon localized regions of the enamel matrix. The conclusion is drawn that any type of metabolic disturbance during amelogenesis will produce a similar mechanism of hypoplastic formation. The variation is only in degree. With very slight irritation, the ameloblasts may leave a granular surface layer of the enamel matrix, and then continue to function normally.

46. SUSCEPTIBILITY TO DENTAL CARIES IN THE RAT. IX. INFLUENCE OF CALCIUM AND PHOSPHORUS AT VARIOUS LEVELS AND RATIOS. *Maxwell Karshan, Ph.D., and Theodor Rosebury, D.D.S., Dental and*

Medical Schools, Columbia University, New York, N. Y. Twelve groups, each of 11 to 13 rats, 22 days old, were given diets containing 13 or 18 per cent saccharose and a constant level (79 per cent) of 30-mesh yellow corn. Calcium lactate was added with or without KH_2PO_4 to graded Ca-P levels and ratios approaching normal conditions for tooth calcification. Viosterol was added to 1 diet with highest levels of Ca and P. To maintain constant corn percentage, starch, agar, starch plus agar, or a silicious abrasive were added. Feeding periods were 56 to 125 days. Rating of fissure caries, from decalcified micro-sections, was made by method previously described (*J.A.D.A.* **21:** 1599, 1934). Results: Reduction of caries was not effected until Ca and P contents of diet rose to 0.27 and 0.19 per cent respectively. From this level to optimal calcifying conditions (including vitamin D), which yielded significant but subtotal reduction of caries index, improvements in Ca-P levels with a ratio within normal limits yielded corresponding reductions of caries index correlated with improvements of calcification of dentin and alveolar bone, and increases in tibia ash. No simple relationship was found between Ca and inorganic P of blood and caries index. Silicious abrasive induced marked attrition of molars but did not reduce caries index.

IX. Fifth Session: Afternoon, March 14; Abstracts 47–56

47. Biochemical studies of the saliva of Greenlanders correlated with dental caries and the occurrence of salivary calculus. *Maxwell Karshan, Ph.D., Poul O. Pedersen, Eli H. Siegel, Sc.B., D.D.S., and Benjamin Tenenbaum, B.S., D.D.S., Dental and Medical Schools, Columbia University, New York, N. Y. and Dental School of Copenhagen, Denmark.* Paraffin-stimulated saliva of natives in 7 settlements in the Julianhaab District, Southwest Greenland, was analyzed for calcium, inorganic phosphate and carbon dioxide combining capacity. The subjects, ranging in age from 14 to 43, were divided into 4 groups—caries-free, arrested-caries, active-caries and miscellaneous. There were 28 caries-free, 9 arrested-caries, 29 active-caries and 21 miscellaneous cases. The mean values for calcium, inorganic phosphate and carbon dioxide combining capacity were greater in the caries-free, arrested-caries and miscellaneous groups than in the active-caries group. The salivary data were regrouped in

relation to the occurrence of calculus. The mean values for calcium, inorganic phosphate and carbon dioxide combining capacity were greater in the group with calculus than in the calculus-free group. The data indicate an inverse relationship between the active-caries and calculus groups. The findings for caries and calculus are similar in direction to those previously reported for clinic patients and Alaskan Eskimos. (*J. D. Res.* **18:** 395, 1939; *J. A. D. A.* **26:** 1965, 1939; *Am. J. Dis. Child.* **57:** 1026, 1939; **59:** 39, 1940).

48. A PLANING MACHINE FOR PLANO-PARALLEL TOOTH SECTIONS. *William Lefkowitz, D.D.S., Columbia University, School of Dental and Oral Surgery, New York, N. Y.* Improvements in the technique of preparing ground sections of teeth aid not only in the examination of such specimens but also yield more sections from each tooth, thus presenting a better 3 dimensional conception. By using a diamond charged phospho-bronze saw for slicing the tooth, it is possible to secure 4 to 5 times as many sections from a specimen. A micrometer determines the thickness of each slice which can be cut at 250 micra. The use of diamond as a cutting agent produces less friction and therefore less heat in the specimen. The specimens are secured to a disc (which can accommodate 12 sections) with quick hardening balsam. The disc revolves against a revolving lap bathed with an abrasive in water. The machine does not require continual supervision. A constant spring pressure is stopped by a micrometer adjustment at which time grinding ceases thus making it possible to determine the thickness of the specimens in advance. Sections are removed by immersion in xylol. By this method all sections are plano-parallel and of uniform thickness.

49. EFFECT OF THYROIDECTOMY UPON GROWING TEETH OF MONKEYS. *Daniel E. Ziskin, D.D.S., and Edmund Applebaum, D.D.S., Columbia University, School of Dental and Oral Surgery, New York, N. Y.* Thyroidectomy and various other related types of operation were performed on 18 monkeys. At least 2 injections of alizarin were made before and after the operations. The alizarin was deposited in the dentin growing at the time of the injection and the red lines established the growth rate before and after the operations. Unerupted molars were dissected out and ground into thin sections for histologic and Grenz ray studies. Thyroidectomy produced a great decrease in daily

rate of dentin formation. Measurements were made with an eyepiece micrometer at various regions of the tooth along the dentinal tubules. In one monkey lack of calcification is very marked in both enamel and dentin. Almost all predentin is formed after the operation. On the other hand, a normal monkey given thyrotrophic hormone, showed a spurt in growth of dentin during the first 10 days and then a gradual decrease of the spurt back to the normal rate of growth within about 40 days.

50. ORAL MANIFESTATIONS OF SYSTEMIC DISEASE. *Thomas J. Cook, D.D.S., School of Dentistry, University of Pennsylvania, Philadelphia, Pa.* This study of general skeletal diseases in which the maxilla or mandible or both may also be involved includes: (a) multiple myeloma, a malignant disease that involves bone; (b) osteitis deformans (Paget's disease), a chronic inflammatory condition which simulates osteoplastic metastasis; (c) osteitis fibrosa cystica (hypoparathyroidism), produced by an excessive parathyroid secretion which is usually associated with a parathyroid tumor; (d) xanthomatosis (Schuller-Christian disease), which usually occurs in children and in which roentgenographic appearance of the lesions in the bones and particularly of the lesions in the skull has been distinctive and a definite aid in diagnosis.

51. SALIVARY MAGNESIUM. *Frances Krasnow, Ph.D., and Edith B. Oblatt, A.B., Guggenheim Dental Clinic, New York, N. Y.* The apparent significance of findings in 1937 (*J. Periodont.* **9:** 42, 1938) indicated a need for the extended work summarized in the present report. It is based on analyses for 191 cases varying in age from 4 to 57 years. Among these are individuals who are (1) without any malfunction as far as medico-dental clinical and laboratory examination could discern, (2) caries-free but have systemic involvement, (3) caries-susceptible without or with other ailments not dental in nature, (4) suffering from erosion (abrasion, wasting) without or with additional pathology. The results not only support those previously published but emphasize the aberrations obtained for groups (3) and (4). In both, the elevated total magnesium content appears characteristic. Alterations of these values is quite possible, the degree of mutability being apparently a function of the amount of adjustment in physiological status. The time interval required for reversion to

the normal average range depends upon the conscientiousness exercised by the patient in adopting the recommended routine.

52. A STUDY OF THE DEVELOPMENTAL COMPONENTS OF DENTIN. *Gerrit Bevelander, Ph.D., College of Dentistry, New York University, New York, N. Y.* A study of the development of dentin has been made in a series of animals including the rat, dog, cat, pig, monkey and human. The first structure which one observes in dentinogenesis is a fibrous membrane which lies between the future odontoblasts and ameloblasts. This membrane is continuous with the dental sac; in the developing pulp cavity it is augmented by the addition of numerous fine argyrophylic fibers. Korff's fibers first appear at the tip of the crown. Taking origin in the pulp, they extend through the odontoblast layer, terminating in the region of the dentino-enamel junction. At the periphery they maintain their argyrophilic character. This zone contains (a) coarse and (b) fine fibers which assume a direction either parallel or tangential to the dentinal tubules. In the circumpulpal dentin the fibers lose their argyrophilic character as calcification occurs. These latter fibers are in some manner associated with the calcification pattern of dentin, the details of which are still to be determined. The development of dentin has been studied in association with the development of membrane bone; these tissues are strikingly similar in their embryonic origin, histogenic components, and morphological appearance.

53. GENERALIZED RAPID ALVEOLAR ATROPHY; ITS SYSTEMIC ASPECTS. *Samuel Charles Miller, D.D.S., William Wolf, M.D., and Benjamin Seidler, B.S., D.D.S., New York University, College of Dentistry, New York, N. Y.* "Generalized rapid alveolar atrophy" (S. C. Miller classification) is a condition which appears predominantly in young females from 18 to 25 years of age. Because of the severity of the disease and the youth of the patients, it seems most likely to be associated with a systemic cause or causes. A series of 20 patients who presented such an oral picture were subjected to a complete oral, physical and laboratory examination. Of the laboratory findings, the most striking is the high calcium level of the blood associated with a low phosphatase activity. Most of the cases evidence a lowered basal metabolic rate. There is consistently, likewise, a flattened glucose tolerance curve which is associated with a lessened specific dynamic

action of proteins. On the findings of the laboratory tests and the clinical picture, the patients will be treated systemically, i.e., with endocrine preparations, where necessary. At the end of the period of treatment, changes in the oral condition, if any, will be noted.

54. PATHOLOGICAL STUDY OF EXPERIMENTAL FUSOSPIROCHETAL LESIONS IN GUINEA PIGS. *Jesse Ehrenhaus, A.B., and Theodor Rosebury, D.D.S., Dental and Medical Schools, Columbia University, New York, N. Y.* Rosebury and Foley (*J. A. D. A.* **26:** 1798, 1939) found that lesions produced in guinea pigs by subcutaneous groin inoculation of fusospirochetal exudate from man, passed through guinea pigs, take 2 extreme forms: localized necrotic foul abscesses which evacuate and heal, and fatal diffuse gangrenous cellulitis. These extremes seem to correspond with mild and severe fusospirochetal disease in man as described by others. Studies of sections, stained with hematoxylin-eosin and by Levaditi's method, of guinea pig lesions of both types and intermediates, showed striking differences also corresponding with descriptions of the pathology of human lesions. Localized lesions showed typical abscess formation with well marked polymorphonuclear infiltration, granulation and fibrosis; fusospirochetal tissue penetration was limited by the polymorphonuclear cell layer. With increasing severity polymorphonuclear cells were replaced by large mononuclear cells, granulation tissue was lacking, spirochetes penetrated into normal tissue, while the rest of the flora was limited sharply to the necrotic layer. In the most severe lesions little or no inflammatory response was present and massive spirochetal invasion of adjacent normal tissue occurred. These findings are in line with other studies which suggest the importance of the polymorphonuclear leucocytes in resistance to fusospirochetal infection. (Published in *Columbia D. Rev.* **11:** 11, 1940.)

55. SURGICAL PATHOLOGY OF THE ACUTE INFECTIONS OF THE TEMPORAL SPACES. *Malcolm Wallace Carr, D.D.S., New York Polyclinic Medical School and Hospital, New York, N. Y.* Recent investigation indicates that acute dental infection arising from either maxillary or mandibular teeth may spread by direct extension and by anatomical continuity to the temporal region, and may involve either one or both potential temporal spaces. Periapical infection originates as an intraosseus infection, but under certain circumstances, perforation of

either the external or internal plate of bone may occur. The infection then becomes extraosseus or subperiosteal, and subsequent sequelae depend to a large degree upon location of the bone perforation. Following perforation of the subperiosteal alveolar abscess, under certain conditions the suppurative process gains access to the contiguous connective tissues of the face or neck, and when pus has formed and is accumulating under pressure, the infection usually spreads by direct extension through loose areolar tissue and along fascial planes and vascular sheaths, tending to localize in potential anatomical spaces, following the line of least resistance. When the pus burrows to loose areolar tissue within thickness of the cheek (buccal fat-pad), the suppurative process may readily extend through this loose areolar tissue, and follow the line of least resistance upward to the superficial temporal space where the temporal areolar tissue is a direct continuation of the buccal fat-pad. The superficial temporal space is bounded superficially by temporal fascia with the temporal muscle lying deeply. Pus may also invade the deep temporal space which is bounded superficially by the temporal muscle and deeply by the periosteum of the temporal bone.

56. THE GRENZ RAY IN THE TREATMENT OF ORAL LESIONS. *Ralph Howard Brodsky, D.M.D., Sea View and Mt. Sinai Hospitals, New York, N. Y.* During the past 3 years, studies have been conducted in the use of the Grenz ray and its effect on various oral lesions. This ray has a wave length between that of the x-ray and the ultra-violet ray; the former being too penetrative for the treatment of most lesions in the mouth, while the latter is too superficial. The Grenz ray can be directed so that 90 per cent of it can be absorbed at the point desired. The effect of the ray was studied on a group of tuberculous patients who manifested tuberculous ulcers in the mouth. One striking observation was the alleviation of pain usually 24 to 48 hours after the first irradiation of the painful ulcers. The ulcers under further treatment either completely disappeared or manifested very definite signs of improvement. In the case of lesions on which other forms of irradiation were previously used, our therapy was retarded. Experimental treatment of various types of periodontal lesions was caried out (several hundred patients). A series of these patients who received Grenz radiations and no sub-gingival scaling or medica-

tions, manifested very marked improvements. Some patients who did not respond to the usual treatments of the periodontist were rendered free from periodontal disease through the added medium of Grenz radiations to their gingivae. Subsequently, lesions such as aphthous stomatitis, dry sockets, lupus, and leukoplakia have responded very adequately to the Grenz ray.

X. Sixth Session: Evening, March 14; Abstracts 57–61

57. Introduction of dr. joseph mcfarland. *Thomas J. Cook, D.D.S. School of Dentistry, University of Pennsylvania, Philadelphia, Pa.* The task assigned me this evening is indeed a most pleasant one and I assure you that the honor implied by this assignment is deeply appreciated. Because of who you are, a great scientific body, and because of who he is, a teacher of pathology, I need not tell you of his scientific attainments. There is, however, one thing I would like to say and that is—he possesses that remarkable ability of enthusing his students in the subject that he teaches, this has been proven by the fact that although roll is never taken in his classroom there is seldom a vacant seat, which, I feel, is a tribute to any teacher. It gives me great pleasure to introduce to you Dr. Joseph McFarland, Professor of Pathology, School of Dentistry, University of Pennsylvania.

58. Remarks. *Joseph McFarland, M.D., Sc.D., University of Pennsylvania, Philadelphia. Pa.* The speaker hesitated to confine himself to any formal subject, simply preferring to make a few "Remarks." It should be noted that this method has had at least one very distinguished precedent, for it will be remembered that after the lengthy, scholarly oration of Everett at Gettysburg, President Lincoln made a few "remarks."

Artemus Ward in his "London Lecture" said "time passes on, which seems to be a kind of way that time has." The passage of time has a way of affecting us all, and none the less the thoughts and activities of university professors. Perhaps it does so most strongly about the time of the momentous occasion of retirement. Old people are prone to dwell upon the past to the disadvantage of the present. They balance the past with the now and often come to the conclusion the visible changes have been for the worse rather than for the better. But

some changes are undoubtedly improvements, and in the line of progress.

Within the life-time of the speaker the paving of the Philadelphia streets has passed in turn from cobble stones (rough and relatively impassable) to wooden blocks, then to Belgian blocks and finally to asphalt (smooth and adequate to carry the rapid motor traffic) and all that is, no doubt, progress. So too transportation has passed from the slow horse-drawn street cars with clattering hooves and jingling bells to cable cars, then to electric trolley cars and finally, largely to speedy motor cars and buses. That also seems to be progress.

But in the same fifty years there have been other changes, many in less visible things. For example, a great decline in old-fashioned large families and comfortable homes with corresponding increase in restricted families living in small apartments, and inevitable loss of the virtue of hospitality and growth of selfishness; increase in the ease with which divorces may be obtained; the development of credit buying that leads to extravagant purchase of unessential things such as automobiles, radios, victrolas, with which time is spent in frivolity that might better be devoted to more lasting satisfaction; frequent defalcation in the payments with consequent bankruptcy; increasing inattention to honesty, thrift, benevolence, truth and other virtues. These are indeed changes, but scarcely in the line of progress!

Fifty years ago while a young medical student at Heidelberg, the speaker felt the impact of the mighty discoveries of Koch, Lister, Pasteur and a host of their colleagues. It was, indeed, a great and stimulating experience, for it marked the beginning of the scientific method of investigation. The rush of young men to Europe in order that they might participate in these activities was only comparable to the rush of gold seekers in 1849.

The new system of scientifically controlled research had come to stay, and had brought a new means of discovery. At first taken up by individuals, institutions followed. Research (with the accent erroneously placed on the re-) soon was not only popular but became compulsory. Men and institutions became known by the research carried on and the results published. It became a fetish to be worshipped. University and institutional administrators attempted to force the output. Reputation, promotion and even salary came to

be determined by the number and importance of the papers a person has published.

Science may be defined as "knowledge acquired through accurate observation and correct thinking," but in many scientific institutions the staffs are forced to research without considering whether they are capable of making accurate observations and without regard for their capacity for correct thinking and of these two qualities the ability to think correctly is the least common.

The need for increased knowledge has never been greater nor more apparent than now, but the search for it is being carelessly overdone. The unfit and incompetent are stimulated to do research, not merely through encouragement but also under compulsion. Time and money are often wasted by those who cannot make accurate observations or do correct thinking, and who fill the work places in institutions to the exclusion of the capable. Driven too hard these investigators may succumb to temptation and work hastily rather than thoroughly. Once an institute attains the enviable record of publishing one hundred papers a year, the squeeze is on, and other institutions are forced in one way or another to meet this competition and better that record. Here is one of the changes occurring with the passage of time. Is it an improvement? Is it progress?

In practice it sometimes seems to work out something like this. Mr. Millionaire having learned that research is impossible though greatly needed in some institution, erects and endows a laboratory with space for ten investigators with technicians i.e., ten well equipped working rooms. There is also a library with books, current journals and a librarian, also animal quarters with attendants, an office for filing and indexing with a clerk in charge and finally a director's suite. But where are the ten competent men to occupy these rooms? That is a question very difficult to answer at the start. Gradually, however, the rooms become filled with likeable, earnest and promising young people. All but one of whom, we will say, sit down in their comfortable rooms without any definite idea of what to do or how to do it, and proceed to amuse themselves, while they live on the donor's bounty. The one with the good problem goes straight to work and soon attains his end, that is, solves his problem. The other nine call repeatedly for suggestions. But after a time the

director gets them to work on something, and now comes the trouble, for publications justifying the expenditure of the money must appear. Mediocre or worthless papers, produced under pressure begin to be ground out, and their size and number, rather than their originality or quality make an impression. If at about this stage an experienced and original man desires to obtain a place in which to conduct an important investigation, he, and others like him have to be turned away because there is no room. The donor is told and he generously adds five more rooms. Then the story repeats itself. When the rooms are finished they must be filled and when the next genius turns up, there is no place so another addition must be built, and so on and on. This shows how time and money are wasted on what is called "Research."

But let me not be misunderstood. Research must not stop. It must go on. It must be fostered and encouraged in every way. However, it is obvious it cannot be forced nor production controlled at will. Those unqualified to do research because they lack aptitude for it cannot be made productive either by encouragement or by financial support. There must be discrimination between activities that are likely to advance knowledge and those that are not.

Research should be as carefully and efficiently managed as any business, and its control and prosecution concentrated in the hands of those who can make accurate observations and think correctly, to place it in any other hands is to court failure.

Above all, if we wish it to continue, great care should be taken not to waste the precious money appropriated for it by supporting an army of drones whose chief interest is selfish desire to make an easy living by amusing themselves.

59. RULDOLF KRONFELD. *Edgar C. Coolidge, D.D.S., Chicago College of Dental Surgery, Chicago, Ill.* (*pages 266–276*).

60. PRESIDENTIAL ADDRESS. *William J. Gies, Ph.D., Columbia University, New York, N. Y.* (*pages 258–266*).

61. INAUGURAL ADDRESS. *Wilmer Souder, Ph.D., National Bureau of Standards, Washington, D. C.* (*pages 276–278*).

XI. PAPERS READ BY TITLE: ABSTRACTS 62–92

62. EFFECTS OF PROLONGED YELLOW PHOSPHORUS MEDICATION ON GROWING LONG BONES AND GROWING TEETH. A ROENTGENOLOGIC

AND HISTOLOGIC STUDY. *Carroll O. Adams, M.D., and Bernard G. Sarnat, M.D., Dept. of Surgery, University of Chicago, and College of Dentistry, University of Illinois, Chicago, Ill.* Thirty-four rabbits and 34 rats 28 to 65 days of age were used for experimental and control purposes. A 0.6 mg. coated pill of yellow phosphorus was given daily to the rabbits and 0.01 per cent to 0.04 per cent yellow phosphorus was added to the cod liver oil of the standard diet for the rats. In the experimental animals a "phosphorus band" in the metaphyses of the growing long bones and the basal bones of the skull is seen as a zone of increased density in the roentgenographs. This same area can be seen grossly in the sectioned specimens and histologically. This effect is believed to be due to a diminution in the resorption of cartilage matrix and bone. No changes are found in the roentgenographs of the growing teeth. Histologically, zones of disturbed calcification are found in the dentin of the rat incisors and molars which correspond closely to the period of ingestion of the drug. Unlike in the long bones, the disturbances of calcification in the dentin of the rat incisor vary with the dosages of yellow phosphorus administered. By the use of roentgenographs, yellow phosphorus in the doses employed could be utilized to measure the rate of growth of endochondral bones but not of teeth.

63. THE CORRECTION OF ERROR IN CEPHALOMETRIC ROENTGENOGRAMS. *J. W. Adams, D.D.S., M.S., College of Dentistry, University of Illinois, Chicago, Ill.* Scales which correct for the enlargement found in lateral headplates taken according to the Broadbent-Bolton technique were devised and applied. Distortion of the head structures is minimized by increasing the anode-object distance to 5 feet. The corrective scales are radiographic images made at 1 cm. film-median plane intervals of an aluminum gauge with leaded gradations which were mounted in the median plane of the machine with its zero in the central ray axis. The validity of the scales was determined by their application to the head-plate tracings of 5 skulls which carried radiopaque markings at significant anatomical sites. A mean of the images of bilateral structures was adopted. The control was established by surveying these same skulls with a Western Reserve Craniostat and plotting the image on accurate graph paper. Measurements of these drawings were made with a standard metric rule. A comparison of the same measurements taken in these 2 manners revealed that

the error in linear dimensions was less than 2 per cent while all angles were opened about 1°. The effect on linear dimensions and facial angles of incorrect head and mandibular positioning illustrates the significance of a painstaking technique. (Published in *Angle Orthodont.* **10**: 3, 1940.)

64. STUDIES OF RETAINED DECIDUOUS TEETH. *M. S. Aisenberg, D.D.S., University of Maryland, Dental School, Baltimore, Md.* Studies of deciduous teeth with and without successors that are in position longer than the normal time show ankylosis in a variety of patterns. Deciduous teeth with successors should be extracted at the normal shedding time, while those without successors (anodontia) are retained for years.

65. FLUORINE CONTENT OF TEETH AND MINERAL SALTS. *W. D. Armstrong, Ph.D., M.D., School of Dentistry, University of Minnesota, Minneapolis, Minn.* Fluorine content of the enamel of deciduous teeth was found to vary between 0.0062 and 0.0081 per cent. Several samples of reagent grade calcium phosphate contained over 0.01 per cent fluorine and reagent grade magnesium salts contained up to 0.0017 per cent fluorine. The latter results emphasize the ubiquitous occurrence of fluorine and indicate that the diets of laboratory animals contain appreciable quantities of this element.

66. THE BRINELL HARDNESS METHOD AS APPLIED TO THE REGISTRATION OF VERTICAL INTERMAXILLARY FORCE. *Claude R. Baker, M.S., D.D.S., P. J. Brekhus, B.A., D.D.S., and R. L. Dowell, Met.E., Ph.D., University of Minnesota, Minneapolis, Minn.* The intermaxillary force of natural or artificial dentures may be measured by an application of the Brinell hardness method. A steel ball 2 mm. in diameter is held between 2 arms of a special instrument. One arm of the instrument is a standardized aluminum plate of known Brinell hardness. When the teeth are brought to bear on the extremities of the arms the steel ball is indented and is subsequently removed and the diameter of the indentation measured with a micrometer microscope. By means of the formula: $BH = \frac{P}{D/2\,(D - \sqrt{D^2 - d^2})}$ where D is the diameter of the ball in mm., d is the diameter of the indentation in mm. and P is pressure in kilograms. A table may be used to read the force directly from the diameter of the indentation.

67. CHRONIC FLUORINE POISONING. *W. H. Bauer, M.D., School of Dentistry, St. Louis University, St. Louis, Mo.* (No manuscript received for publication.)

68. HISTOLOGICAL FINDINGS IN SLEROSIS OF JAWS. *W. H. Bauer, M.D., School of Dentistry, St. Louis University, St. Louis, Mo.* (No manuscript received for publication.)

69. REPAIR OF PERIDENTAL TISSUES IN THE RODENT AND THE CAT. *T. D. Beckwith, Ph.D., and Willard C. Fleming, D.D.S., School of Dentistry, University of California, San Francisco, Cal.* A dental instrument was passed through the gingiva, bone, peridental membrane and into the dentin of the teeth of guinea pigs, rabbits and kittens. The animals thus treated were sacrificed at intervals over a period of several weeks and the histologic changes observed. Immediately following the operation inflammation appears. Infection is almost always present. Destruction of peridental fibres occurs on the surface of the alveolar process. In the rodent, repair begins about the seventh day as shown by the formation of granulation tissue and beginning reconstruction of peridental membrane upon the tooth surface rather than upon the bone. Among the observations made were, the formation of an amyloid-like structure in the pulp, new formation of dentin and occasional repair of alveolar bone by cartilage. Resorption and ankylosis are also observed. In some animals, finely divided calcium carbonate and silica were placed in the wounds. Where calcium carbonate was used the peridental fibres reappeared, but there was a depression of the formation of bone. The presence of the silica did not markedly affect the reformation of peridental fibres.

70. STUDIES CONCERNING THE ORAL CAVITY AND SALIVA. *Robert E. Brawley, D.D.S., M.S., and Jobe H. Sedwick, D.D.S., School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.* V. PHOSPHORUS (Inorganic phosphorus content of resting and activated saliva of children). Salivary phosphorus determinations were made on the resting and activated saliva of 758 school children, 522 males and 236 females, ranging in age from 6 to 17 years. There were no significant differences in the mean values with age or sex. The mean values for resting saliva were consistently higher than mean values for activated saliva. (Resting saliva 12.53 mgs. phos. per 100 cc.; activated 11.15 mgs. phos. per 100 cc.)

VI. HYDROGEN-ION CONCENTRATION (pH of resting and activated saliva of children). Electrometric pH determinations (quinhydrone electrode) were made on the resting and activated saliva of 791 school children ranging in age from 6 to 17 years. The group was composed of 547 males and 244 females. All determinations were made at least 1 hour after breakfast and immediately after collection. No significant difference exists between the mean pH values of males and females of the various age groups. There is a significant difference between the mean values of the 2 types of saliva. The mean pH value of the resting saliva is 6.77 and 7.45 for the activated saliva.

VII. RATE OF FLOW (Rate of flow of resting and activated saliva of children). Rates of flow of resting and activated saliva were determined on 767 apparently healthy school children, 519 males and 248 females, ranging in age from 6 to 17 years. Mean values for the activated saliva are approximately 3 times those of resting saliva. (Paraffin was chewed to stimulate flow.) This is true for both males and females. Mean values increase with age for males and females and for both types of saliva. Mean values for males are greater than those for females in all age groups and for both types of saliva. The mean values found were: Resting saliva:—males, 519 cases, 0.51 cc./min.; females, 248 cases, 0.35 cc./min.; both males and females, 767 cases, 0.46 cc./min. Activated saliva:—males, 518 cases, 1.41 cc./min.; females, 246 cases, 1.07 cc./min.; both males and females, 764 cases, 1.30 cc./min.

71. STUDIES ON THE RELATIONSHIP OF THE MANDIBULAR FIRST MOLAR TO THE MANDIBLE. *Earl S. Elman, D.D.S., Graduate School, University of Illinois, Chicago, Ill.* This paper presents the findings of a study of the normal relationship of the mandibular first molar to the mandible taken from 72 control cases, and compares these findings with those made from a study of the same relationship in 42 Class II malocclusions (Angle). The studies were made by graphing and analyzing corrected measurements taken from tracings of radiographic headfilms. The linear measurements charted, vertical and horizontal respectively, were taken from the lower border of the mandible, and from the posterior border of the ramus, to the distal contact point of the mandibular first molar. The angles, formed between the lower border of the graph and lines drawn from the zero point to each

charted measurement, were tabulated. From these tables and graphs the following conclusions were drawn: 1. The vertical measurement is equivalent to approximately two-thirds of the horizontal measurement in each of the cases studied. 2. The mandibular first molars of the cases studied, bear, in at least 2 planes of space, a definite relation to the mandible. 3. This constant relationship prevails not only prior to but after the molar has come into occlusion. 4. This relationship appears identical in both the control and Class II cases included in this study. (Published in *Angle Orthodont.* **10:** 24, 1940.)

72. SIZE OF DENTINAL TUBULES. *Eduard G. Friedrich, D.D.S., Northwestern University Dental School, Chicago, Ill.* The tubular diameter is being observed in various teeth of persons of different ages at the pulp, cementum, and in the crown, to determine behavior of the diameter along the length of the tubule. Diameter at the pulp averages 1.74 microns and at the cementum 0.90 microns in ground sections. These values are somewhat smaller than reported heretofore.

73. HISTOLOGIC AND EXPERIMENTAL ANALYSIS OF CONICAL TOOTH FORMS. *Fred Herzberg, D.D.S., M.S., and Maury Massler, B.S., D.D.S., University of Illinois, College of Dentistry, Chicago, Ill.* From the simple cone which is the basic tooth form of many animal species more complicated morphologic types are evolved. Histologic analysis of ground sections of conical teeth of fish, frog, snake, alligator, cat, dog and opossum show the incremental pattern of dentin to be a series of simple cones, or modifications thereof, one within the other. Gross studies were made of these teeth and those of the wild boar, whale and tiger. Experimental analysis by vital injections of 2 per cent alizarin Red S confirmed the incremental pattern of growth. Measurements between successive injection effects gave the rates and gradients of growth in the dentin. Average for 40 frogs was 1.5 microns per day, for 13 snakes 4.7 microns and for 1 alligator was 2.3 microns. The growth conformed to the general laws of growth for other parts and organs (Huxley). Gradients of growth observed microscopically are correlated with gross curvatures of the tooth. The incremental pattern of growth may be used as a guide to analysis of tooth form as well as stages in appositional growth. Classification of conical forms of teeth: I. Simple Cone. No gradient of growth or curvature is

evident. (Fish). II. Lingually Curved Cone. A distinct labio-lingual gradient of growth is evident. The true logarithmic spiral form. (Snake). III. Lingually Curved and Laterally Sheared Cone. Mesio-distal or antero-posterior gradient of growth is superposed upon the labio-lingual gradient. The laterally sheared logarithmic spiral form. (Alligator).

74. EXCHANGE OF RADIOPHOSPHATE BY DENTAL ENAMEL. *Georg von Hevesy, D.Sc., F.R.S., and W. D. Armstrong, Ph.D., M.D., Institute for Theoretical Physics and Laboratory of Zoophysiology, Copenhagen, Denmark.* The enamel of the mature permanent teeth of cats was separated by 2 independent methods 4 days after subcutaneous injection of very potent preparations of radioactive phosphate. Per gm. the activity of the enamel was 6.7 to 10 per cent of that of dentin. 0.0023 to 0.0076 per cent of the total activity was found per gm. of enamel. The P^{32} content of the enamel became constant on repeated purification indicating insignificant contamination with dentin. Experiments in vitro showed that the P^{32} acquired by enamel in vivo is apparently not derived from saliva. The results indicate a slow exchange of phosphorus but not an ability of enamel to undergo significant changes of composition after eruption, as a result of nutritional alterations.

75. THE RATE AND PATTERN OF ERUPTION AS DEMONSTRATED BY INJECTIONS OF ALIZARIN RED S. *M. M. Hoffman, D.D.S., M.S., and I. Schour, D.D.S., Ph.D., University of Illinois, College of Dentistry, Chicago, Ill.* Sixty-seven animals were given multiple intraperitoneal injections of a 2 per cent isotonic solution of alizarin Red S (100 mgm/kilo), from birth to 500 days of age at intervals of 2 to 30 days. The effects of alizarin Red S on alveolar bone, primary dentin and secondary cementum permit study in ground sections of tooth movement in relation to bone. Measurements of eruption rates were made from the cemento-enamel junction (fixed point on tooth) to alizarin Red S effects on alveolar crests (stable marking in bone). Independent method utilizing rate of root elongation and fundic-bone apposition show similar rates. The width of the periodontal membrane at the fundus remains constant. Results show continuous eruption, the rate of which decelerates from birth to 500 days. Fastest rates are found prior to 35th day. Eruption begins with earliest

evidence of calcified enamel and dentin (lower first molar 1–2 day). Molars move occlusally, anteriorly, and laterally. Attrition, secondary cementum and alveolar bone growth continue to 500 days and possibly throughout life. There is definite evidence of mesial drift which is a component of physiologic migration and eruption. The position of Hertwig's epithelial sheath changes with eruption. Quantitative studies from radiographs and skull material confirm histologic findings and permit an analysis of the relation of dentition to craniofacial growth.

76. PATHOLOGIC STUDY OF VITAL PULPS. *D. A. Kerr, A.B., D.D.S., Schools of Medicine and Dentistry, University of Michigan, Ann Arbor, Mich.* (No manuscript received for publication.)

77. SALIVARY EXCRETION OF SULFANILAMIDE AND THE ACCOMPANYING EFFECT ON MOUTH FLORA. *E. J. Kocour, M.D., Ph.D., and E. A. Zaus, B.S., M.D., Northwestern University Dental School, Chicago, Ill.* Experiments in which the free and conjugated sulfanilamide of the saliva and blood were compared after daily doses of 60 grains of sulfanilamide over a period of 5 days were conducted on 5 patients at the Cook County Hospital. Also, for a period of 5 days prior to administration, counts of the aciduric and normal flora of the mouth were made. No conjugated sulfanilamide was found in the saliva. All was in the free state. The salivary content was usually less by 1 to 2 milligrams per cent than the blood, but, in occasional specimens, it was approximately that of the blood. The bacterial growth on plain dextrose agar showed no reduction. On the fifth day, however, in 3 of the subjects, the aciduric organisms showed a very definite drop. It was thought that the organisms depressed were yeast, acid streptococci, and staphylococci. As the experiments were not carried beyond the fifth day, one must draw conclusions with reservations as to the fifth day drop in the aciduric organisms.

78. THE EFFECT OF VARIOUS FOODS ON THE BUFFERING POWER OF SALIVA. A PRELIMINARY REPORT. *E. J. Kocour, M.D., D.D.S., and E. A. Zaus, B.S., M.D., Northwestern University Dental School, Chicago, Ill.* Non-stimulated saliva was collected at intervals of 1, 2, and 3 hours following various diets. The acid neutralizing power of this saliva was determined by titrating it with 0.020 N lactic acid. The pH of the saliva, during this procedure, was determined by a glass

electrode. Titration curves were plotted and the number of cubic centimeters of acid required to reduce 100 cc. of saliva to a pH of 6 and 5 respectively, was determined. Ninety determinations were made on 2 adult male subjects. We believe that neither the number of subjects nor the available data are sufficient to warrant any definite conclusions. We have found that the saliva produced after the ingestion of a diet rich in carbohydrate required approximately 8 cc. less 0.020 N lactic acid per 100 cc. of saliva to reduce the pH to 6, and 10 to 15 cc. less to reduce it to a pH of 5, than that required to correspondingly reduce saliva produced during the post absorptive state. The saliva produced following the ingestion of a diet rich in fat required approximately 8 cc. more of 0.02 N lactic acid per 100 cc. of saliva to reduce the pH to 6, and approximately 10 cc. more to reduce it to a pH of 5, than that required to correspondingly reduce saliva produced in the post absorptive state. Protein food (animal protein) apparently has little influence upon the neutralizing power of the saliva. Saliva collected during or shortly after speaking has a lowered neutralizing power.

79. On the relation of dental enamel to fluor-apatite. *J. F. McClendon, Ph.D., Hahnemann Medical College, Philadelphia, Pa.* Crystals of fluor-apatite in saliva lose no appreciable weight in 3 months unless the pH is 5 (or more acid) (*J. D. Res.* **3:** 50, 1921). Feeding fluorine to rats led to the opinion that fluorine is necessary for sound teeth (*Rock Products*, **26:** 27, 1923) and chemical analysis has shown that sound teeth contain more fluorine than carious (*J. D. Res.*, **17:** 27, 1938). Newly weaned rats were placed on double distilled water and a diet adequate for growth and reproduction containing 0.45 parts of fluorine per million of the dry diet, with controls on the same diet but with 22 parts of fluoride per million of water. The animals on the low fluorine regime have dental caries and refuse to gnaw hard cereal grains whereas those getting additional fluorine eat the hardest whole grains until there is not a trace left. Teeth cleared in benzyl benzoate and mounted in clarite-x show caries in all low fluorine rats. Tea should be a good source of fluorine in the diet. The dry ash of Ceylon tea was green which turned to red on solution, due to manganese. Tea contained 60 p.p.m. of fluorine. Absence of cations and pH 3 improves the thorium-alizarin method of analyzing microgram quantities of fluorine.

80. DETERMINATION OF DIETARY FLUORINE WITH THE MCCLENDON-BRATTON APPARATUS. *J. F. McClendon, Ph.D., and Wm. C. Foster, Hahnemann Medical College, Philadelphia, Pa.* A method for determining micro quantities of dietary fluorine was devised. The method utilizes the McClendon and Bratton automatic stoker, pipet electrode vessel and galvanometer. The ash of an unknown of 10 grams can be read in micrograms within 2 per cent and the fluorine content determined.

81. FIRST REPORT ON THE STUDY OF THE EFFECT OF AMMONIACAL SILVER NITRATE SOLUTION ON DENTAL CARIES. *Guy S. Millberry, D.D.S., College of Dentistry, University of California, San Francisco, Cal.* A committee of the Alumni Association of the University of California College of Dentistry has promulgated a plan to investigate the effect of sodium nitrate and ammonium hydrate (as outlined by J. W. Prime) on dental caries. Printed forms were distributed to 174 operators. Twenty-three (13.2 per cent) returned 127 forms, 25 (14.3 per cent) returned all forms with no report and 126 (72.5 per cent) made no returns. Of the 127 forms returned omissions and errors made rejection of all or part of some records necessary. One clinic group reported 20 cases satisfactorily and will be continued for 5 years and another reporting 64 cases will require careful follow up due to misunderstandings. Caries progressed on 4 to 6 per cent of the surfaces in 3276 teeth reported to date. The study will be continued during the next 4 years.

82. A STATISTICAL STUDY OF TORUS PALATINUS. *Samuel Charles Miller, D.D.S., and Harry Roth, B.S., D.D.S., New York University, College of Dentistry, New York, N. Y.* The palates of patients were examined as they entered the dental clinic for treatment. The following classification was used (measurements approximate):

	ELEVATION	WIDTH	LENGTH
SLIGHT	2–3 mm.	under 5 mm.	under 10 mm.
MODERATE	3–6 mm.	5–10 mm.	10–15 mm.
MARKED	above 6 mm.	above 10 mm.	above 15 mm.

The case number, age, sex, and the number of teeth present in the maxillae were also recorded. Over 2000 cases were examined. In order not to give undue weight to any age group, an equal number of cases for each group was selected at random from the accumulated

data. Persons 65 years of age and over were excluded from all the tabulations and calculations because they represented approximately only 2 per cent of the age distribution of the clinic and were too few in number to make an equally valid sample. Conclusions: The occurrence of torus palatinus before the age of 5 is rare. It first occurs as a slight torus at the age of 7. Torus palatinus occurs in 24.2 per cent of the population and is twice as frequent in females as in males. The torus palatinus appears to grow. The average time elapsed in growing from slight to moderate is 5.7 years, from moderate to marked, 8.4 years.

83. LIGHT FROM PRIMITIVE RACES ON MODERN DEGENERATION. *Weston A. Price, D.D.S., M.S., Cleveland, Ohio.* A comparison of the isolated groups of primitive racial stocks with members of those same stocks in various stages of modernization, has revealed that where contact with modern civilization has included the displacement of native foods with modern foods of commerce, chiefly white flour, sugar products, canned goods, vegetable fats and polished rice, there not only has been a change in the incidence of dental caries from less than 1 per cent of the teeth attacked to an average of 30 per cent, in many groups twice that amount; but also a change in the physical architecture, particularly of the face. This has occurred in even the first generation following change in foods eaten by parents. Later born members of given families when compared with the earlier born have frequently shown a progressive increase in these injuries. Evidence has developed that the origin of these changes in physical design is associated with defects in germ cells of one or both parents and that these injuries to the germ cells are directly related to absence of certain dietary factors, especially vitamins A and E. Evidence has developed that these physical defects are associated in some cases with deficiencies in development of certain brain structures and that these defects are associated with modified individual personality and behavior. Important corroborating evidence is provided by animal nutritional studies in which typical severe lesions are produced by planned vitamin deficiencies of the parental stock. Educational programs are indicated for nutritional reinforcements of parents-to-be on the basis of practices of several primitive races studied.

84. DIMENSIONAL CHANGES OF COPPER AMALGAM. *E. W. Skinner, Ph.D., and H. Wormington, D.D.S., M.S.D., Northwestern University*

Dental School, Chicago, Ill. The dimensional changes of a copper amalgam have been studied by means of the dental interferometer as to effect of trituration time, temperature of heating, and time of heating. It was found that the amalgams contracted under all conditions of manipulation. The amount of the contraction depended upon the temperature of heating; the lower the temperature, the less the contraction. Time of heating had no effect upon the amount of contraction, but a prolonged heating period changed the shape of the dimensional change curve much in the same manner as for higher temperatures. No effect of trituration time was observed. A theory is given for the effects observed.

85. OBSERVATIONS ON THE DURABILITY OF MOTTLED TEETH. *Margaret Cammack Smith, Ph.D., University of Arizona, Tucson, Ariz.* Observations recorded herein give evidence of the danger of addition of fluorides to public water supplies, a method suggested by Cox (*J. D. Res.* **18:** 869, 1939), as an "attractive means for mass reduction of dental caries." A survey of the inhabitants of St. David, Arizona, where the water supplies range from 1.6 to 4 parts per million of fluorine, showed that although mottled teeth may be more resistant to the onset of carries, caries once started is highly destructive. Only 1 person beyond the age of 21 years was found free from caries. That the result of caries development was especially disastrous was reflected in the finding that in almost 100 per cent of the people, certain carious teeth had been extracted following unsuccessful efforts to repair them. Attempts made to anchor the fillings usually resulted in a breaking away of the whole tooth. More than 50 per cent of all age groups beyond the age of 23 years had artificial dentures.

86. CLINICAL AND BACTERIOLOGIC STUDY OF VITAL TEETH. *Ralph Sommer, D.D.S., M.S., and Mary Crowley, A.B., M.S., School of Dentistry, University of Michigan, Ann Arbor, Mich.* (No manuscript received for publication.)

87. METHOD OF STUDYING SKULL DEVELOPMENT OF LIVING RAT AND MONKEY BY SERIAL ROENTGENOGRAMS. *John M. Spence, D.D.S., M.S., University of Illinois, College of Dentistry, Chicago, Ill.* Using a standard dental x-ray machine, lateral serial cephalometric roentgenograms of the same living rat have been obtained from birth to 300 days of age. Occlusal dental films are held in an aluminum casette which in turn is placed in a calibrated movable rack. This rack is

used in conjunction with a calibrated movable ear post so that it is possible to position the head of the rat in the midline. In order to obtain a satisfactory radiograph, the rat is anesthetized with ether or .03 per cent nembutal. The dosage depends on the age and weight of the animal and is controlled so that the duration of anesthesia is about 30 minutes. No anesthesia is necessary until the 7th day. Exposure time on regular occlusal films with no screen is 6 to 9 seconds with a 17 inch target distance. A similar apparatus with a few modifications is employed in a study of the living monkey using no anesthesia (head immobilized by towel) and $\frac{1}{2}$ to $1\frac{1}{4}$ seconds exposure with ultrafast 5 x 7 film, high definite screen and a 30 inch target distance.

88. BACTERIAL DECALCIFICATION OF ENAMEL AND DENTIN. *J. F. Volker, D.D.S., University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.* The relationship between acid production and enamel and dentin weight losses was studied. One hundred milligram samples of tooth substance were incubated at 37°C. with 10 cc. of glucose broth containing pure cultures of oral organisms. Four strains of lactobacilli and 2 strains of streptococci were tested. The acid production of the organism was followed by titration with .1 N NaOH and the weight loss of the tissue determined gravimetrically. Readings were taken at 6, 8, 12 and 24 hours for the streptococci and 24, 48, and 72 hours for the lactobacilli. In approximately 75 tests with dentin and 30 tests with enamel, the observed weight loss was proportional to the acid production of the bacteria. Under these conditions no appreciable difference in the solubility of the enamel and dentin from carious or non-carious and deciduous or permanent teeth could be observed. Rat dentin was found to accelerate bacterial acid production. Artificially and naturally fluorosed dental tissues were more resistant to bacterial decalcification than normal control tissues. The amounts of tooth substance destroyed by streptococci in 12 hours and by lactobacilli in 48 hours were comparable.

89. ON THE BITING STRENGTH OF ALASKAN ESKIMO. *Donald B. Waugh, D.D.S., School of Dental and Oral Surgery, Columbia University, New York, N. Y.* The strength of the jaws of the most primitive Eskimos on the American continent, as recorded by L. M. Waugh,

was compared with those of semi-civilized natives. For this comparison, the gnathodynamometer designed by Brekhus and Armstrong was used, and accurate readings in pounds pressure were recorded. Also, an attempt was made to link the presence of caries, which seems to be in direct proportion to the amount of white man's food used, with reduction of jaw strength.

90. FATTY CHANGES IN TOOTH PULPS AND DENTIN. *Hugh Wilson, A.B., Northwestern University Dental School, Chicago, Ill.* Disclosure of stainable fat in dentinal tubules has been reported briefly by at least 5 investigators with the conclusion that fatty degeneration and changes of Tomes fibers were constantly associated with caries of dentin as well as with extensive erosion and abrasion. Forty-eight teeth with extensive caries, 12 with marked abrasion, 3 with erosion and 9 grossly normal were carefully examined for fat by well recognized methods. Marked fatty changes were found only 5 times in this group of teeth, 3 with caries, 1 with abrasion and 1 grossly normal. In each of these 5 instances extensive degenerative or inflammatory changes in pulps with fatty degeneration of the odontoblasts seemed to have preceded extensive and striking fatty changes in the dentinal tubules. Fatty change was limited to tubules associated with fatty odontoblasts and adjacent regions of pulp disease. Occasional single tubules containing stainable fat are common in carious dentin but massive changes are conspicuously absent.

91. THE EFFECT OF REMOVAL OF THE MAJOR SALIVARY GLANDS IN RATS. *E. A. Zaus, B.S., M.D., and W. G. Skillen, D.D.S., Northwestern University Dental School, Chicago, Ill.* As a result of observation of rampant decalcification in a child with apparently congenital xerostoma a study of similar disfunction upon the teeth of animals was undertaken. Montgomery had conducted such an experiment upon dogs and Kanthak upon monkeys. In neither case were changes in the teeth produced. Rats were selected because caries has been described in them as the result of diet. Various groups of the salivary glands were removed and complete removal of major glands was performed, but caries was not produced using either the Tisdall or the coarse corn caries diet of Hoppert et al. Adding 2 per cent dextrose to the Hoppert diet, in 5 rats with complete removal of the major salivary glands and in 1 of 5 unoperated rats, was followed by produc-

tion of extensive caries-like lesions. Various degrees of cusp caries occurred. When extensive, these involved the occlusal cusp slopes and invaded the pulp. Bacteria were always present in the tubules. No proximal caries was observed. Gingivae remained normal. In all cases severe bone changes occurred with an excessive production of osteoid tissue encroaching upon the peridental membrane and fusing with root surface which in spots was undergoing resorption. An excessive amount of uncalcified dentin, and especially cementum, also occurred. This would seem to indicate nutritional disturbance not observable clinically.

92. REPORT ON THREE CASES OF CONGENITAL DYSFUNCTION OF THE MAJOR SALIVARY GLANDS. *E. Zaus, B.S., M.D., and G. W. Teuscher, D.D.S., M.S.D., Northwestern University Dental School, Chicago, Ill.* In 2 of the cases reported there was complete dysfunction, in the other there was slight activity from 1 of the sub-lingual glands. There was rapid destruction of the enamel with no respect for contact or tooth form. The tips of the cusps are as liable to be affected as any other part of the tooth surface. The cementing substance is destroyed and the enamel rods fall away. Available evidence points to this condition as congenital with failure of the major salivary glands to develop. Other congenital defects may be associated, such as failure of the tear ducts. It is apparent that all treatment to promote the activity of the major salivary glands is doomed to failure. This was illustrated in our cases when they were subjected to diathermy, and injection of the parasympathetic stimulant beta methyl acetyl choline either by subcutaneous administration or by iontophoresis. Explanation of the rampant destruction of the teeth because of the salivary dysfunction involves the following factors: 1. Immunological protection of the saliva; 2. Absence of buffering action of the saliva; and 3. Cleansing action of the saliva.

93. THE EFFECT OF CASTRATION AND HYPOPHYSECTOMY ON THE GINGIVAE AND ORAL MUCOUS MEMBRANES OF RHESUS MONKEYS. *Daniel E. Ziskin, D.D.S., School of Dental and Oral Surgery, Columbia University, New York, N. Y.* Three groups of animals were studied: a normal control of 10; a castrate group of 4 females and 3 males; an hypophysectomized group of 5 females. In the female castrate group tissue biopsies were taken at intervals before the animals were sacri-

ficed as well as post mortem. Microscopical sections showed the earliest change to be the altered arrangement of the prickle cells, more columnar in shape and disposed in vertical rows. Later changes consisted of loss of the keratin layer, pyknosis of the nuclei in the basal cell layer, some lysis of the cells and a stripping off of the superficial layers in sectioning leaving visible only the basal layers. In general the picture was one of marked tissue degeneration. The hypophysectomized series showed, microscopically, alterations similar to those in the female castrate group, only more extreme quantitatively. Staining in both these groups was faint and greyish lavendar in color. Microscopic study of the male castrates revealed an enlarged keratin layer extending onto the mucous membranes. Epithelial pearls were seen. Staining reactions were deep, bright eosin in color. On the whole there were no evidences of degeneration, in fact, the hyperkeratinized tissue bore a close resemblance to tissue which had been treated with the estrogenic hormone.

XII. Necrology*

C. K. Bryant, p. 327; *R. Kronfeld*, p. 328; *J. L. Payne*, p. 328.

Mrs. Carrie Kirk Bryant: 1883–1939

Mrs. Carrie Kirk Bryant was born in Philadelphia, January 6, 1883, and died unexpectedly December 19, 1939. She was the second daughter of Edward Cameron Kirk, late dean of the School of Dentistry, University of Pennsylvania. Mrs. Bryant received her education at the University of Pennsylvania and subsequently enjoyed the opportunities for study at the Philadelphia City Laboratory and at the Laboratory of Hygiene of the University of Pennsylvania under Doctors C. Y. White and Nathaniel Gildersleeve. Her first interest was in biology but soon became focused on bacteriology. She joined the Faculty of the Dental School in 1917 as an instructor and became Assistant Professor of Bacteriology in 1926, in which position she continued up to her death.

She was a member of the American Association for the Advancement of Science, Society of American Bacteriologists, the International Association for Dental Research, and Sigma Xi.

*Fifth annual report of the Necrology Committee.

Her activities in the Department of Bacteriopathology were many, and her influence was unsurpassed. Her special technical knowledge, her grasp of the objectives of dental education, her understanding of human nature, her wide culture, and tireless diligence made her an admirable teacher and friend. She will be missed by all with whom she was associated and her passing is a serious loss for the school which she served so faithfully and well for so many years.

RUDOLF KRONFELD: 1901–1940

(See pages 266–276)

JOSEPH LEWIN PAYNE: 1872–1939

Joseph Lewin Payne, of London, England, born September 25, 1872, suddenly passed away at his professional residence January 31, 1939, as a result of heart failure.

One of the early entrants at the Dental School of Guy's Hospital following its establishment, he soon proved himself one of her most famous dental surgeons, in due course becoming Dental and Consulting Surgeon to the hospital and lecturer in the Dental School. He was President of the leading dental and scientific societies of his country—the Metropolitan Branch of the British Dental Association; the Odontological Section of the Royal Society of Medicine; and the British Society for the study of Orthodontics, as well as the recipient of many other honors. He served in the medical hospitals during the World War and was a member of the London section of our Association.

His breadth of knowledge, enthusiasm and untiring energy enabled him to contribute much to scientific literature, his most outstanding work being his classification of odontomes. But his unbounded interest in all phases of living carried him beyond his chosen professional field into other realms, including general education and social betterment.

Wherever he went, all who came in close contact with him gave him friendship and everlasting respect. There is no doubt that his passing has left a vacancy which will be difficult to fill.

XIII. Executive Proceedings

A. Reports of Secretary and Council

Secretary: James P. Piggott of the New Haven Section resigned and his resignation became effective automatically. This, with transfers, reduces the New Haven Section to one member, Bert G. Anderson, who recommends that the Section be discontinued. Three members were lost by death, James Lewis Payne, Carrie Kirk Bryant and Rudolph Kronfeld. With the approval of the Council two new sections have been formed, Palestine and Houston. According to the action of the Association at the Cleveland meeting and with the required subsequent approval of the Council, the Dental Materials Group was formed for the purpose of advancing group objectives. With the approval of the Council the recommendation of the President in his annual address that the secretary collect the annual apportionments assessed the members has been put into effect. Because of delay in arranging the details of this transfer, section delinquencies will not be reported. However attention should be directed to the fact that there is at least one section that has not participated in any way in the activities of the Association.

Council: In addition to matters already listed above (Secretary's report), the Council, between general meetings, ratified the election of honorary vice-presidents; with the aid of a special committee (Kronfeld, Schour, Hatton) determined the time and place for the current annual meeting; nominated candidates for the general offices to be placed on the ballot for general distribution; and approved a plan for the conduction of the election of officers in the emergency caused by the death of Dr. Kronfeld.

In sessions at the Benjamin Franklin Hotel approved the presentation of the following resolution for adoption by the Association:

Whereas, Major Fernandez E. Rodriguez, D. C., U. S. A., an early member of this Association, was an outstanding pioneer investigator of oral bacteriology; was one of the first to isolate lactobacilli from carious teeth and to emphasize their importance in the

causation of dental caries; made important contributions to the technique of research in this field; conducted a survey into the incidence of dental caries, pyorrhoea alveolaris and other oral diseases affecting American Indians; contributed to the differential diagnosis of sprue, pellagra and other tropical diseases; investigated the relative merits of antiseptics as oral disinfectants; made important early observations regarding the prevalence and etiology of mottled enamel; studied the influence of rachitic diets on tooth development in animals, and whose promising career was cut short by his untimely death, and

Whereas, the American College of Dentists proposes this week to dedicate a memorial tablet to honor Major Rodriguez and his achievements.

Therefore, be it resolved by this Association at its Eighteenth General Meeting in Philadelphia, that this greatly deserved recognition of the service of Major Rodriguez to dental research be highly commended and cordially endorsed, and

Be it further resolved that these resolutions be presented at the dedication of the memorial tablet and that copies be sent to the American College of Dentists and the Dental Corps of the United States Army.

Modified the regulations with reference to program items which have to do with industrial research to read as follows: Industrial research may be reported if the work was done in a "non-profit" institution and the results its own property, but any industrial research may be reported when unanimously approved by the program committee of the Association.

Approved the 54 nominees for membership, listed on pages 336–338, as eligible for election. Recommended that the Publication Committee of the *Journal of Dental Research* together with the President, President-elect and Secretary be authorized to meet with the representatives of Dental Survey to determine all available facts concerning their offer with reference to the publication of the *Journal* and to formulate a recommendation to the Council and Association. Reported favorably on plan to cooperate informally with New York Section in observance of the twentieth anniversary of the founding of the Association to be held at about the time of the Greater New York Meeting in December, 1940. Advised the appointment of a committee to consider methods to increase the circulation of the *Journal of Dental Research*. Recommended the appointment of a committee to devise ways and means to expend the Samuel M. Gordon gift to stimulate quality of papers at the general meetings. Nominated Charles F. Bodecker for the office of Vice-president for the ensuing year. Authorized the trustees to transfer each quarter endowment funds from checking accounts to insured savings accounts

in the banks patronized and up to the maximum amounts allowed. This will not exceed $3,000 per quarter and the interest earned at the rate of two percent per annum. And approved the voluntary discontinuance of the New Haven section.

B. EXECUTIVE SESSIONS

Minutes of the Seventeenth General Session were approved with two corrections. On page 296 insert the name of *Karshan* in the list of members from whom ballots were received. On page 295 change the statement which begins of third line of Addendum and reads "and approval of the request of the Endowment Committee of the Journal of Dental Research to be permitted to invest their funds safely," to read as follows: "All funds received for the endowment of the Journal of Dental Research shall be segregated and transferred to the Trustees of the Association for custody and safe investment." The foregoing acts and reports of the Secretary and Council were accepted and approved, including the election of all nominees for membership approved by the Council and listed on pages 336–338; the adoption of the Rodriguez resolution and the reports of the Treasurer of the Endowment Fund and its audit. The election tellers, Doctors Bibby and Cox, reported the results of the official ballot. Ballots were received from the following members:

Aisenberg, Applebaum, Arnim, Arnold, Baker, Beall, Bear, Becks, Bernier, Beube, Bevelander, Bibby, Bier, Blayney, Bodecker, Bossert, Boucher, Boulger, Boyle, Brandhorst, Brashear, Brekhus, Brodie, Brodsky, Brown (R. K.), Bryan, Bunting, Carr, Cheyne, Clough, Cowlings, Cox, Coy, Crane, Crawford, Crowley, Darlington, Deakins, Dean, Denton, Dunning (W. B.), Easton, Edwards, Erickson, Finn, Fleming, Fosdick, Freeman, Frey, Friesell (F. C.), Friesell (H. E.), Gies, Goldman, Gordon, Grossman, Hadley, Hahn, Hall, Harrison, Hatton, Hellman, Higley, Hill, Hodge, Hoffman, Holliday, Husband, Hutchinson, Jordan, Kaiser, Karshan, Keilty, Kelsey, King, Kitchin, Klaffenbach, Klein, Kotanyi, Krasnow, Krogh, Lalonde, Lasater, Lasby, LeFevre (Mrs. Manley), Lefkowitz, Leonard, Lewis, Lischer, Lowery, Luckhardt, Lundquist, Main, McCollum, McCrea, McFarland, Manley, Marshall, Mead, Meisel, Merkeley, Merritt, Midgley, Millberry, Miller (H. A.), Moore (G. R.), Morse (F. W., Jr.), Mueller (E.), Neustadt, Neuwirth, Noyes (H. J.), Oblatt, Orban, Paffenbarger, Peyton, Podolin, Pond, Price, Robinson (H. B. G.), Rosebury, Rule, Ryder, Salzman, Scherer, Schoonover, Schour, Sedwick, Shapiro, Siegel, Simmonds, Skillen, Skinner, Smith (M. C.), Sognnaes, Sorrin, Souder, Speidel, Stafne, Sweeney, Taber, Taylor (N. O.), Taylor (P. B.), Taylor (W. C.), Thoma, Thomson (H. S.), Trimble, Tunnicliff, Turner, VanHuysen, Volker, Ward, Wasserman, Waugh, Wheeler, Willett, Worman, Wright (G. H.), Zander. Total—157.

Due to the emergency caused by the Dr. Kronfeld's death and his official election as President for the ensuing years, thereby creating a vacancy, at the recommendation of the Council and according to parliamentary procedure, President and President-elect were chosen by advancing the just elected President-elect (Souder) and Vice-president (Schour) to the positions of President and President-elect. The votes were unanimous. The vacancy in the Vice-presidency thereby created was filled by the unanimous election of the Council nomination, Charles F. Bodecker. Council was authorized to approve the election of the Honorary Vice-presidents. List of the officers elected appears on page 336. Report of the committee appointed last year to revise the constitution and by-laws was received and the committee authorized to submit the revision to the membership for either approval or rejection (pages 339–344). Ordered the General Secretary to thank the Local Arrangements Committee, the Deans of both of the Philadelphia dental schools, the lantern operators, the Benjamin Franklin Hotel and the Philadelphia Chamber of Commerce for many courtesies and assistance shown the officers and members of the Association. Reports were received from the members of the Publication Committee of the Journal of Dental Research. Report of the Treasurer and auditors not received, to be filed with the Council subject to their approval.

Adjourned.

EDWARD H. HATTON, *General Secretary.*

C. JOURNAL OF DENTAL RESEARCH

a. Committee on Endowment

WILLIAM J. GIES ENDOWMENT FUND*

Financial Statement as of March 10, 1940

Compiled by L. M. WAUGH, Treasurer

American College of Dentists	1,000
N. Y. Academy of Dentistry	500
L. M. Waugh	200
A. H. Merritt	460
Dental Society of N. Y. State	250

* This is an abridged copy of the report and lists only receipts for the past year and the balances on hand at the beginning and close of the year. Report of March 15, 1939 appeared in the *J. Den. Res.*, 18, 297, 1939.

Omicron Kappa Upsilon	1,000
G. C. Paffenbarger	25
Harry Kaplan	50
In memoriam: John and Ophelia E. Gies	300
Alpha Omega Fraternity, Bronx	25
Assoc. of Military Surgeons (Dental Sec.)	200
Florida Dental Society	100
W. H. G. Logan	100
Fred A. Richmond, Interest	2.25
Arkansas State Dental Assoc	144.50
New Jersey State Dental Assoc	70
H. C. Fixott, Portland, Oregon	2
W. C. Webb, Ashland, Va	1
Passaic Co. Dental Soc	36
M. J. Lentz, Clifton, N. J	10
W. H. Daniels, Paterson, N. J	1
V. P. Klapacs	1
H. W. McMillan, Roseville, Ill	1
R. E. L. Pattilo, Moultrie, Ga	11
T. A. Grant, Savannah, Ga	8
N. H. Slunghier, Athens, Ga	16
R. H. Byrnes, Atlanta, Ga	1
J. E. Chace, Ocala, Fla	10
Atlanta Dental Society	20.73
J. E. Tyler, Worcester, Mass	5
J. B. Poindexter, Huntington, W. Va	5
E. A. Ambrecht, Wheeling, W. Va	5
E. D. Douglas, Parkersburg, W. Va	5
A. J. Boydston, Fairmont, W. Va	5
A. N. Drury, Boston, Mass	2
M. A. Fuller, Springfield, Mass	2
Tenth District Dental Society, Georgia	10
A. C. Brousard, New Orleans	5
F. J. Genre, New Orleans	5
P. E. Smith, New Orleans	5
E. A. Gamard, New Orleans	5
J. E. Psayla, New Orleans	5
Seventh District Dental Society, Georgia	5
E. J. Durkee, West Los Angeles	1
Eleventh District Dental Society, Georgia	13
Lewis Davis, Douglas, Ga	1
Atlantic Co. Dental Society, N. J	9
Sixth District Dental Society, Ga	10
Donations Veterans Adm. Facility (20)	20
G. S. Callaway	25
B. E. Lischer	75
W. B. Dunning	50
S. E. Davenport	25

J. E. Gurley	50
Queens District Dental Society	25
C. H. Schott	25
A. W. Lindsay, China	99.80
B. E. Erikson	100
H. D. Grubb	75
H. W. Krogh	50
Chicago Section, I. A. D. R	25
New York Section, I. A. D. R	25
A. J. Irving	10
West Coast Dist. Den. Soc., Fla	12.50
C. R. Wells	10
A. J. Asch, N. Y	10
E. F. Briggs, Bangor, Me	5
Jacob Schneer, N. Y	30
L. A. Cadarette, Detroit	5
A. I. Hadley, Boston	20
L. J. Porter, N. Y	5
E. C. Blaisdell, Portsmouth, N. H	1
A. R. Cooke, Syracuse, N. Y	10
F. B. Bostwick, Gibralter	5
C. L. Inman, Baltimore	5
Adams Bailey, N. Y	25
J. P. Winthrop, Wilmington	10
W. S. Leslie, Fresno, Calif	5
A. B. Luckhardt, Chicago	10
V. H. Frederich, St. Louis	5
G. B. Broadhurst, St. Louis	10
C. C. Smith, Peoria, Ill	5
M. L. Christensen, Oshkosh, Wis	1
S. P. Rushing, Eldorado, Ark	10
J. R. Mitchell, Atlanta, Ga	5
H. E. Summers, Huntington, W. Va	5
C. A. Wiethoff, Minneapolis	5
A. R. Schmid, Worthington, Minn	2
D. W. Brock, St. Louis	5
J. A. Brown, St. Louis	10
C. S. Copeland, Rochester, N. H	5
C. H. Tweed, Tucson, Ariz	10
R. E. Price, Wilmington	25
Albert Hallenberg, Fargo, N. D	5
G. W. Kuhn, Xenia, O	2
R. B. Giffen, Sacramento, Calif	5
Anonymous, I. A. D. R	25
Springfield Dist. Den. Soc., Missouri	25
D. H. Glew, Washington, D. C	1
W. B. Power, Seattle	1
R. L. Dement, Atlanta	2

F. E. Downs, Batavia, Ill	2
Anonymous, I. A. D. R., Washington Sec	11
R. L. Blake, San Francisco	10
E. G. Sloman, San Francisco	5.00
Total	$5.693.78
On Hand, March 15, '39	15,275.30
Total Receipts up to March 10, 1940	20,969.08

b. Publication Committee

Separate reports were given by the Editor, Business Manager and Circulation Manager. The reports presented the encouraging picture of a slight increase in number of pages over the previous year, a small balance in the treasury and an increase in the number of *paid* subscribers. On the other hand all worthy material could not be included in a volume of the present size, the total number of copies circulated has decreased somewhat and advertising has not been appreciably increased.

Editorial.—There were 579 pages in Volume 18, devoted to 42 scientific papers and to the Proceedings of the Association. During the year 1939, 54 manuscripts were received and 7 were returned to their authors. The 42 published papers were contributed from 16 American universities, 2 foreign universities, 1 research institute (American) and from 2 unaffiliated authors (1 foreign).

Business.—The Treasurer's report covers the period March 2, 1939 to December 31, 1939. The balance as of March 2, 1939 was $3,533.95; receipts March 2-December 31, $2,076.09. The cost of publication of Volume 18 was: Printer (printing, binding, mailing, etc.), $3,904.35; expenses of editor, business manager and circulation manager, $506.44; total, $4,410.79.

Circulation.—The actual press run has been reduced in accord with cancellation due to non-payment for subscriptions. The subscriptions paid for Volume 19 will not be less than those for Volume 18 and it is believed that the number can be increased. Negotiations are under way with the societies whose members have, in the past, received gratis copies. The gratis copies will be discontinued but it is hoped that many will continue as paid subscribers. A detailed classification of subscribers and distribution was given.

D. LIST OF OFFICERS AND NEW MEMBERS ELECTED

a. Officers (1940–41)

HONORARY: *Vice-presidents*—R. Gordon Agnew, Chengtu. George B. Pritchard, London. H. Pichler, Vienna. J. C. Middleton Shaw, Johannesburg. B. Gottlieb, Palestine.

ACTIVE: *President*—Wilmer Souder, National Bureau of Standards. *President-elect*—Isaac Schour, University of Illinois. *Vice-president*—Charles F. Bodecker, Columbia University. *Treasurer*—Bissell B. Palmer, N. Y. Policlinic Medical School and Hospital. *Secretary*—Edward H. Hatton, Northwestern University. *Trustee of the Endowment Fund* (three years)—Russell W. Bunting, University of Michigan.

b. New Members[1]

Ann Arbor, Mich. Paul H. Jeserich, A.B., D.D.S. and Ralph F. Sommer, M.S., D.D.S., Dental School, University of Michigan.

Bayonne, New Jersey. Edmund M. Wise, B.S. and Raymond N. Vines, Research Laboratory, International Nickel Co.

Bethesda, Maryland. John W. Knutson, D.D.S., C.P.H., Carroll E. Palmer, M.D., Ph.D. and George St. J. Perrote, A.B., A.M., National Institute of Health.

Boston, Mass. Paul N. Losch, D.D.S., George Earl Thompson, D.M.D. and Morton F. Yates, D.M.D., Dental School, Harvard University.

Chicago, Ill. Zelma Baker, B.S., Ph.D., Zoller Memorial Dental Clinic, Elizabeth S. Hemmens, B.S., University of Chicago (Bacteriology Department), Ellis B. Jump, A.B., D.M.D., Zoller Memorial Dental Clinic; Gerald J. Reed, D.Sc. and Joseph S. Restarski, D.D.S., M.D.S., Chicago College of Dental Surgery, Loyola University; George W. Teuscher, D.D.S., M.S.D., Northwestern University Dental School, and George D. Wessinger, B.S., Ph.D., Chicago College of Dental Surgery, Loyola University.

Cincinnati, Ohio. Samuel Rabkin, D.D.S. (Private Practice).

[1] A list of the members, as of Dec. 10, 1939, was published in the *J. D. Res.*, **18**: 566, 1939. A list of the members elected in 1939 was published in the *J. D. Res.*, **18**: 301, 1939.

College Park, Md. Lawrence H. James, B.Sc., Ph.D., Bacteriology Department, University of Maryland.

Columbus, Ohio. Milton Berman, M.S. and Harry D. Spangenburg, D.D.S., M.S., Dental School, Ohio State University.

Copenhagen, Denmark. Ove Brinch, M.D., Knud-Mogens Christophersen, L.D.S., Frode Hilming, L.D.S., Johs. Juul Holst, L.D.S., M.D. and P. O. Pedersen, L.D.S., Dental School of Copenhagen.

Johannesburg, South Africa. Thomas W. Osborn, D.Phil., M.Sc., M.R.C.S., L.R.C.P., Medical School, University of the Witwatersand.

London, England. Martin A. Rushton, M.A., M.B., B.Ch., L.D.S., Guy's and St. Thomas Hospitals.

Melbourne, Australia. Howard K. Worner, M.Sc., Australian College of Dentistry.

Minneapolis, Minn. Kenneth W. Ray, A.M., Ph.D., Director of Research, General Refineries, Inc.

New York, N. Y. Meyer Klatsky, D.D.S., (Private Practice).

Orlando, Florida. Wilbur M. Davis, D.D.S. (Private Practice).

Oslo, Norway. Guttrom Toverud, Ph.D., Dental School of Norway.

Philadelphia, Pa. William E. Ehrich, M.D., Pathology Department, University of Pennsylvania Medical School, Leroy M. Ennis, D.D.S., University of Pennsylvania Dental School, J. T. Gore, D.D.S., (Private Practice), Mary M. Moore, D.D.S., (Private Practice), and D. Leonard Rosenthal, D.D.S., (Private Practice).

San Diego, Cal. Raymond A. Lowry, D.D.S., Dental Corps U. S. Navy.

San Francisco, Cal. Sidney Epstein, D.D.S. and Ernest G. Sloman, D.D.S. and A. H. Throndson, B.Sc., D.D.S., College of Physicians and Surgeons.

Stockton, Cal. James T. Sweeney, D.D.S., California State Hospital.

Washington, D. C. Clarence P. Canby, D.D.S., Army Dental School, Elias Elvove, B.S., Ph.D., National Institute of Health, Brigadier Gen. Leigh C. Fairbank, D.D.S., Office of Surgeon General, U. S. Army, H. F. Fraser, A.B., M.D., National Institute of Health, Raleigh Gilchrist, A.B., Ph.D., National Bureau of Standards, Maurice A. Goldberg, D.D.S., Georgetown University Dental School, Peter Hidnert, A.B., Ph.D., National Bureau of Standards, Frank J.

McClure, B.S., Ph.D., National Institute of Health, Carl A. Schlack, D.D.S., Naval Dental School, William H. Sebrell, Jr., M.D., National Institute of Health and Lt. Col. Roy A. Stout, Walter Reid General Hospital.

E. MEMBERS PRESENT AT ONE OR MORE SESSIONS

SECTIONS. *Ann Arbor:* Jay, Peyton. *Boston:* Baker, Boyle, Cushman, Miner, Morse (F. B., Jr.). *Chicago:* Blayney, Coolidge, Denton, Figg, Freeman, Hatton, Hine, Logan, Noyes (F. B.), Noyes (H. J.), Pendleton, Orban, Schour, Shell, Skinner, Tunnicliff, Zander. *Cleveland:* Hill, Taylor. *Columbus:* Boucher, Kitchin, McFarland. *Houston:* Elliott, Kotanyi. *Iowa City:* Bryan, Speidel. *Louisville:* O'Rourke. *Minnesota:* Brekhus, Lasby, Rudolph, Stafne. *New Orleans:* Tiblier. *New York:* Applebaum, Beube, Bevelander, Bodecker, Breitner, Brodsky, Cahn, Carr, Crawford, Gies, Holliday, Karshan, Krasnow, Lefkowitz, Leonard, Miller, Newman, Rosebury, Siegel, Silvers, Waugh, Weinmann. *Philadelphia:* Appleton, Burkett, Churchill, Cook, Crowell, Grossman, Turner. *Pittsburgh:* Cox, Friesell (H. E.), Wright. *Richmond:* Arnim, Bear, Clough, Coy, Hall. *Rochester:* Bibby, Cheyne, Deakins, Finn, Garrison, Hodge, Manley, Volker. *St. Louis:* Bauer, Gurley, Hampp, Lischer, Robinson, Wheeler. *Washington:* Arnold, Barber, Dean, Kaplan, Klein, Krogh, Paffenbarger, Schoonover, Souder, Sweeney. *Unattached:* Coleman, Gordon, Moore (T. E.), Nichols. *Norway:* Sognnaes. Total—105. (All U. S. Sections except Baltimore and San Francisco represented in attendance.)

XIV. Addendum

a. Revised form for Constitution proposed by the Special Committee on Revision of Constitution

Article I. Name

This organization is named: International Association for Dental Research.

Article II. Objects

The Association has been established (*a*) to promote broadly the advancement of research in all branches of dental science, and in the related phases of the sciences that contribute directly to the development of oral health-service, and which add to the knowledge of the mouth and teeth and of their relations to the body as a whole; and, further, (*b*) to encourage and facilitate coöperative effort and achievement by, and mutual helpfulness among, investigators in all nations in every division of stomatology; (*c*) to the end that dentistry may render cumulatively more perfect service to humanity.

Article III. Membership

SECTION 1. *Eligibility.* Any person who has conducted, and published an account of, a meritorious original investigation in dental science, or in any of the sciences contributory to oral health-care, is eligible to membership in the Association, provided such person conforms to the recognized standards of professional ethics.

SECTION 2. *Nomination.* (A) Nominations to membership may be presented to the Council at any time, for consideration at the succeeding annual meeting of the Association.

(B) The Council shall promptly determine, for each nomination, whether the nominee meets the requirements of eligibility, and at the first succeeding annual meeting shall report to the Association the findings relating to each eligible nominee.

SECTION 3. *Election.* (A) Election of new members may occur only at annual meetings of the Association.

(B) Election to membership shall be by ballot. A two-thirds affirmative vote of those present and voting shall be necessary for election.

SECTION 4. *Initiation.* Initiation of membership requires delivery to the Secretary-treasurer of a signed acceptance of election thereto.

SECTION 5. *Discontinuance.* (A) Membership may be automatically terminated, by a member, by delivery of a formal notice to the Secretary-treasurer of that member's resignation.

(B) Membership may be automatically discontinued, for any member, by delivery to the member of a formal notice from the Secretary-treasurer of the decision, at an annual meeting of the Association by a two-thirds vote of those present and voting, that the member's association has been terminated.

Article IV. Divisions

SECTION 1. *Organization.* Members in any nation, with the approval of the Association, may organize a Division for the national advancement of the objects of the Association.

SECTION 2. *Management.* The affairs of a Division shall be managed by its members in harmony with the requirements of the Constitution and By-laws of the Association.

Article V. Sections and Groups

SECTION 1. *Organization.* Members in any geographical center, with the approval of the corresponding national Division, may organize a Section for the local advancement of the objects of the Association.

SECTION 2. *Management.* The affairs of a Section shall be managed by its members in harmony with the requirements of the Constitution and By-laws of the Association, and of the By-laws of the corresponding national Division.

SECTION 3. *Groups.* (A) Members in any branch of dental science, with the approval of the Association, may organize a Group for the group advancement of the objects of the Association.

(B) The affairs of a Group shall be managed by its members in harmony with the requirements of the Constitution and By-laws of the Association.

Article VI. Meetings

SECTION 1. *Annual.* The Association shall meet at least once annually.

SECTION 2. *Special.* Special meetings of the Association may be convened by the Council.

Article VII. Officials

SECTION 1. *Council.* (A) Authority. During the periods between annual meetings of the Association, the executive management of its affairs shall be conducted by the Council, in accord with the general authority voted by the Association.

(B) Personnel. The Council shall consist of (*a*) the general active officers and (*b*) one representative of each Section.

(C) Representatives. (*a*) The representatives of the Sections in the Council shall be elected, and their terms of service determined, by the respective Sections.

(*b*) Each Group may have an advisory representative in the Council, to be selected by the Group.

SECTION 2. *General officers.* (A) The general active officers of the Association and of the Council shall be a President, a President-elect, a Vice-president, a Secretary-treasurer, an Editor, and five Trustees.

(B) Honorary officers may be elected, by the Association, from nominations by the Council, or by Divisions, Sections, or Groups.

(C) Nomination. One or more nominations for each active and honorary office for the succeeding term shall be formally announced, for the Council by the Secretary-treasurer, to each member of the Association at least six months before the date of the annual meeting at which election will occur, and in a form to indicate that independent nominations may be made by the individual members.

(D) Election. (*a*) Four months before the succeeding annual meeting, the Council's nominations for each office, and each independent nomination supported by five or more

nominators, shall be sent by the Secretary-treasurer to all members of the Association on an official ballot-form for a vote at that meeting.

(*b*) A plurality of the votes cast shall elect to each office.

(E) Term of service. (*a*) The elective term of service for each officer of the Association, excepting the Editor and Trustees, shall be one Association year.

(*b*) The elective term of service for the Editor shall be two years.

(*c*) The elective term of service for each Trustee shall be five years. Upon adoption of this provision, additional Trustees shall be elected, on conditions to be determined by the Council, to make the total number five, for terms ranging from one to five years, one expiration of term to occur annually thereafter, each successor to be elected for a full term of five years.

(*d*) Each officer shall continue to serve until the installation of his duly elected successor.

(F) Vacancies. An ad-interim vacancy in any office, for any cause, shall be filled promptly for the unexpired term by a majority vote of the Council. Any vacancy that might occur either at, or during the progress of a ballot preceding, an annual meeting of the Association, shall be filled by the Association, on recommendations by the Council, by a majority of the members present and voting.

Article VIII. Finances

SECTION 1. *Amount of dues.* At each annual meeting of the Association the amount of the annual dues, payable by each member before the close of the succeeding annual meeting, shall be determined and announced by the Council, and may not exceed five dollars ($5.00) or its approximate equivalent.

SECTION 2. *Restriction of expenditure of funds.* No funds of the Association may be expended by the Council, or by any officer, without general or specific authorization by the Association.

Article IX. Journal

SECTION 1. *Title.* The *Journal of Dental Research* is the Association's official periodical publication.

SECTION 2. *Board of Editors.* (A) The *Journal* shall be conducted, for the Association, by a Board of Editors consisting of (*a*) the Editor of the Association, (*b*) a representative of each Section, and (*c*) additional members elected by the Association.

(B) The Editor shall be chairman of the Board.

(C) Publication of the *Journal* shall be in charge of an executive committee of three members - the Publication Committee - to consist of the Editor, and two additional members to be elected by the Association.

(D) All members of the Publication Committee shall be included in the Board of Editors.

SECTION 3. *Term of service.* (A) The elective term of service of each member of the Board of Editors who directly represent the Association, including the Publication Committee, shall be two years.

(B) Each such member shall be eligible for reelection.

(C) The representatives of the Sections in the Board of Editors shall be elected, and their terms of service determined, by the respective Sections.

SECTION 4. *Endowment Fund.* (A) Funds received for the endowment of the *Journal* shall be segregated for this purpose by, and shall be in the custody of, the Trustees.

(B) Payments of income from the Endowment Fund of the *Journal* may be made only on authorizations by the Association.

Article X. By-laws

By-laws may be proposed at any annual meeting of the Association, and may be adopted at the same meeting by a two-thirds vote of the members present and voting.

Article XI. Quorum

Thirty members shall constitute a quorum of this Association when at least three Sections are represented in that number.

Article XII. Amendments

SECTION 1. *Constitution.* (A) Presentation. A proposed amendment of this Constitution, formally endorsed by at least five members and accompanied by a statement of reasons for adoption, may be presented at any annual meeting, and thereupon becomes a special order for a vote at the succeeding annual meeting.

(B) Notification of all members. The Secretary-treasurer shall send to each member of the Association, not later than six months after the annual meeting at which an amendment was proposed, (*a*) a printed copy of the amendment, (*b*) the names of the sponsors and stated reasons for its adoption; and (*c*) a blank ballot for a vote on the amendment.

(C) Vote. (*a*) At the next, or any succeeding, annual meeting, all of the foregoing conditions having been met, announcement of the results of the vote on pending amendments shall be in order.

(*b*) A proposed amendment shall become a part of this Constitution when at least a majority of the entire membership of the Association vote for its adoption.

SECTION 2. *By-laws.* Amendments of the By-laws may be proposed at any annual meeting of the Association, and may be adopted at the same meeting by a two-thirds vote of the members present and voting.

BY-LAWS

Section A: Membership

1. NOMINATION. (A) Copies of an official form for the presentation of all nominations for membership, as authorized by the Council, shall be issued to the members by the Secretary-treasurer (III, 2, A).

(B) Before a nomination can be officially presented to the Council, it must be formally endorsed by at least three members who certify that the candidate for membership is eligible (III, 2, A).

(C) Each endorsed nomination for membership must be accompanied by a copy of at least one publication showing that the nominee meets the scientific requirements of eligibility (III, 2, B).

2. ELIGIBILITY. (A) The word "published" in Section 1 of Article III is interpreted to mean published in print and available, directly or in reprint form, for presentation to the Council.

(B) Publication by oral presentation, as an abstract, or in any other incomplete form, does not meet the requirement of eligibility.

3. ELECTION. By vote of at least two-thirds of the members in attendance at a

meeting the Secretary may be instructed to cast a ballot, for the Association, for one or more nominees (III, 3, B).

4. SECTIONS OR GROUPS. (A) Assignment of a member to a Section or Group shall be optional for all concerned, and may be made by agreement between the member and a Section or Group (V).

(B) Secretaries of Sections and Groups shall promptly notify the Secretary-treasurer of the Association of changes in sectional and group memberships.

(C) Each Section or Group shall be free to elect any person to be an "associate" member of the Section or Group. "Associate" members of a Section or Group are neither members nor "associate" members of the Association, and may not be enrolled as such.

5. DISCONTINUANCE. Any member who has failed for three years in succession to pay his annual dues to the Association, and whose reason for the delinquency has not been accepted by the Council or by the Section of which he is a member, shall, at the end of the third year of delinquency, automatically forfeit membership in the Association; and shall be notified promptly by the Secretary-treasurer of the said termination (III, 5, B).

Section B: Payment of dues

1. SECTIONAL APPORTIONMENTS. (A) Dues of the members of the Association who are also members of Sections shall be payable directly to the respective Sections, and shall be transmitted to the Association by the Sections in sectional apportionments (VIII, 1).

(B) Dues of a member of the Association who is also a member of a Group shall not be payable to a Group, nor to the Association through a group apportionment.

2. NON-PAYMENT OF DUES. (A) Non-payment of dues by members of Sections shall not reduce the amounts of sectional apportionments currently payable to the Association.

(B) After a membership in the Association has been terminated for non-payment of dues, the amount of that member's delinquency, as paid to the Association by a Section, shall be returned to the Section.

3. EXEMPTIONS. (A) Annual dues for the fiscal year in which membership may be terminated by a member or by the Association shall be repaid or, if unpaid, shall not be demanded (III, 5).

(B) In any year the Council may suspend payment of dues by members resident in countries in which the annual meeting of the Association will not be held (VIII, 1).

(C) Members in good standing for twenty full years of continuous membership shall thereafter be exempt from payment of dues to the Association, and shall not be included in calculations of sectional apportionments payable to the Association (VIII, 1).

(D) Rights of membership shall not be affected by any remission of dues.

Section C: Meetings

1. ANNUAL. The place and time of each annual meeting, when not voted by the Association, shall be determined by the Council (VI, 1).

2. PROGRAM. (A) The arrangements for each annual meeting of the Association shall be made, in accordance with the Council's rules, by an executive committee of the Council – the Program Committee – to consist of the Secretary-treasurer, the President and the President-elect (VI, 1).

(B) The Secretary-treasurer shall be Chairman of the Program Committee.

Section D: Officials

1. DUTIES. (A) The duties of the officers shall be those conventionally associated with the official titles, and such other duties as the Association, the Council, or the Board of Editors, may assign (VII, IX).

(B) Each general active officer shall report annually to the Council on the conduct of his office (VII, 2).

(C) The Council, and the Trustees as a group, shall report annually to the Association on the nature and scope of their proceedings (VII, 1, 2).

2. INSTALLATION. At each annual meeting an appropriate ceremony of installation, determined by the Council, shall inaugurate the term of service of each general active officer (VII, E).

3. HONORARY. An Honorary Vice-president may be nominated by, and elected from, each Division or sectional equivalent outside of North America (VII, 2, B).

Section E: Journal

1. OFFICERS OF PUBLICATION COMMITTEE. (A) The two members of the Publication Committee additional to the Editor shall serve respectively as Business Manager and Circulation Manager (IX, 2, B).

(B) The Business Manager shall be the Secretary-treasurer of the Board of Editors (IX, 2, A).

2. EXECUTIVE ASSISTANTS. The members of the Publication Committee, as the executive committee of the Board of Editors, may appoint assistants, subject to approval by the Board (IX, 2, C).

3. ANNUAL REPORTS. The Board of Editors and the Publication Committee shall report annually to the Council on the condition of the *Journal* under their management (IX).

Section F: Committees

1. *Standing and special* committees may be designated, for particular functions, by the Association, Council, or Board of Editors.

2. *Appointments* to membership in all committees, excepting personnel specified in motions creating committees, shall be made by the President of the Association.

b. The William John Gies Award, Research Fellowships and Grants-in-Aid of the American College of Dentists

The Committee on Dental Research take pleasure in reporting that the accomplishment of two primary objectives, the initial bestowal of the William John Gies Award and the assignment of the first Research Fellowships and Grants-in-Aid, has coincided appropriately with the Centennial of organized dentistry.

Our first word must be an expression of grateful appreciation to the committee from the International Association for Dental Research who so loyally and effectively assisted the Research Committee of the American College of Dentists in developing the mechanism by which these awards were to be made. In undertaking the necessary survey

of the need and opportunity for promoting dental research, our greatest encouragement and reassurance lay in the fact that we could look to the International Association for Dental Research for guidance and support, relying upon the valuable experience gained by them in their continuous efforts towards the scientific solution of dental problems, and the standards of quality and intelligence which have been set by their distinguished *Journal of Dental Research*. The Association listened cordially to a preliminary outline of our plans and projects, and lent to our deliberations the services of a cooperative committee, whose information, advice and support have been available at all points, and, needless to say, of inestimable service in the attainment of our objectives. We are indeed most grateful to these gentlemen. The value and significance of being in touch with minds striving toward the upbuilding of dental science, and the intrinsic worth of their assistance in setting up definite standards and regulations, will be an enduring influence, we hope, in making the administration of our research funds an increasingly effective stimulus to professional and scientific growth.

In accordance with the policy of the College to give public recognition to one who in any field of science has made an outstanding contribution to the progress of dentistry, the Centennial Celebration in Baltimore was selected as a most fitting occasion for the initial William John Gies Award of the College. It was therefore bestowed, on March 17, 1940, upon Peter John Brekhus of Minneapolis, for distinguished services in the cause of dental education and research in this country. The Award, in the form of a suitably engrossed citation, was presented not only to glorify the recipient in the eyes of his fellow-workers, thus adding to the prestige of the quietly effective labors to which our research-workers are faithfully devoting themselves, but also to acknowledge, as openly and strikingly as possible, the debt of all members of our profession to whose who fulfil in highest measure the avowed function of us all to enlarge the scope of dental science so far as experience, ability and opportunity will permit. It is the earnest hope of our Committee that the simple ceremony at Baltimore may have impressed upon the public at large the fact that we the whole body of our profession are engaged upon an endless quest, to seek out the ultimate laws of health and discover more and more surely the principles which govern their application to human welfare.

Our Research Fellowships and Grants-in-Aid are intended as a practical expression of this same fundamental need in our professional life—a need not only of the results which research may produce, but also of the pervading influence of the spirit of research. We must live not only in the present, with its task and its reward; but with the zest of fresh discoveries and new insights which may lie just ahead—with the constant expectation that old difficulties will vanish as the forces of nature are better understood. Little by little we can gain upon the vast areas of the unknown; and to promote this conquest the research funds have been awarded, with our best wisdom and discrimination, after due study of the credentials and projects of the applicants by a sub-committee which had previously set up the necessary mechanism of appropriation, application, supervision, and publication of results. The names of the successful applicants, with the sums awarded, the inquiries and where they are to be pursued, are as follows:

1. Dr. Harrison R. Hunt, Dr. Carl A. Hoppert } $100.00 Michigan State College
   "Inheritance factor in resistance and susceptibility to dental caries in rats"
2. Dr. Albert H. Kniesner $500.00 Western Reserve, School of Dentistry
   "The factors in saliva which influence the growth of L. acidophilus and are indicative of the presence or absence of dental caries"
3. Dr. Sidney B. Finn $1200.00 Univ. of Rochester, School of Dentistry
   "The effect of applications of sodium fluoride in preventing and controlling dental caries in children"
4. Dr. Samuel Seltzer $500.00 Dental School, Univ. of Pennsylvania
   "The anti-bacterial action of drugs which have been recommended for cavity sterilization"
5. Dr. M. L. Tainter $400.00 College of Physicians & Surgeons, San Francisco, Calif.
   "The general problems involved in the evaluation of the abrasiveness of dentifrices and their individual constituents"
6. Dr. James Nuckolls $500.00 Dental College, Univ. of California
   "The primary centers of lobular development, growth and calcification in the tooth"
7. Dr. B. Orban $500.00 Northwestern University Dental School
   "Wound healing after different methods of gingivectomy and post operative treatment"
8. William J. Furuta $1000.00 College of Dentistry, University of California
   "Histologic study of the effect of various mineral deficiencies in dental and oral structures in animals"

In conclusion, may we stress once more our dependence upon the interest, the advice and the practical cooperation of the International Association for Dental Research and of all others who share our expectation of substantial benefit from this activity, in knowledge, in professional relationships, in public confidence and support.

ALBERT L. MIDGLEY,
Chairman.